INFLUENCE OF SUCTION PRESSURE ON THE CAPACITY OF A SIX - CYLINDER PACKARD ENGINE

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INFLUENCE OF SUCTION PRESSURE ON THE CAPACITY AND ECONOMY OF A SIX-CYLINDER PACKARD ENGINE

A THESIS

PRESENTED BY

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H. F. Gebhardt 5/29/15

H. M. Raymond

L. C. Monin

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Roger C. Palmer.
Emil Stepanek.
Frank G. Cooban.

Chicago, Illinois.

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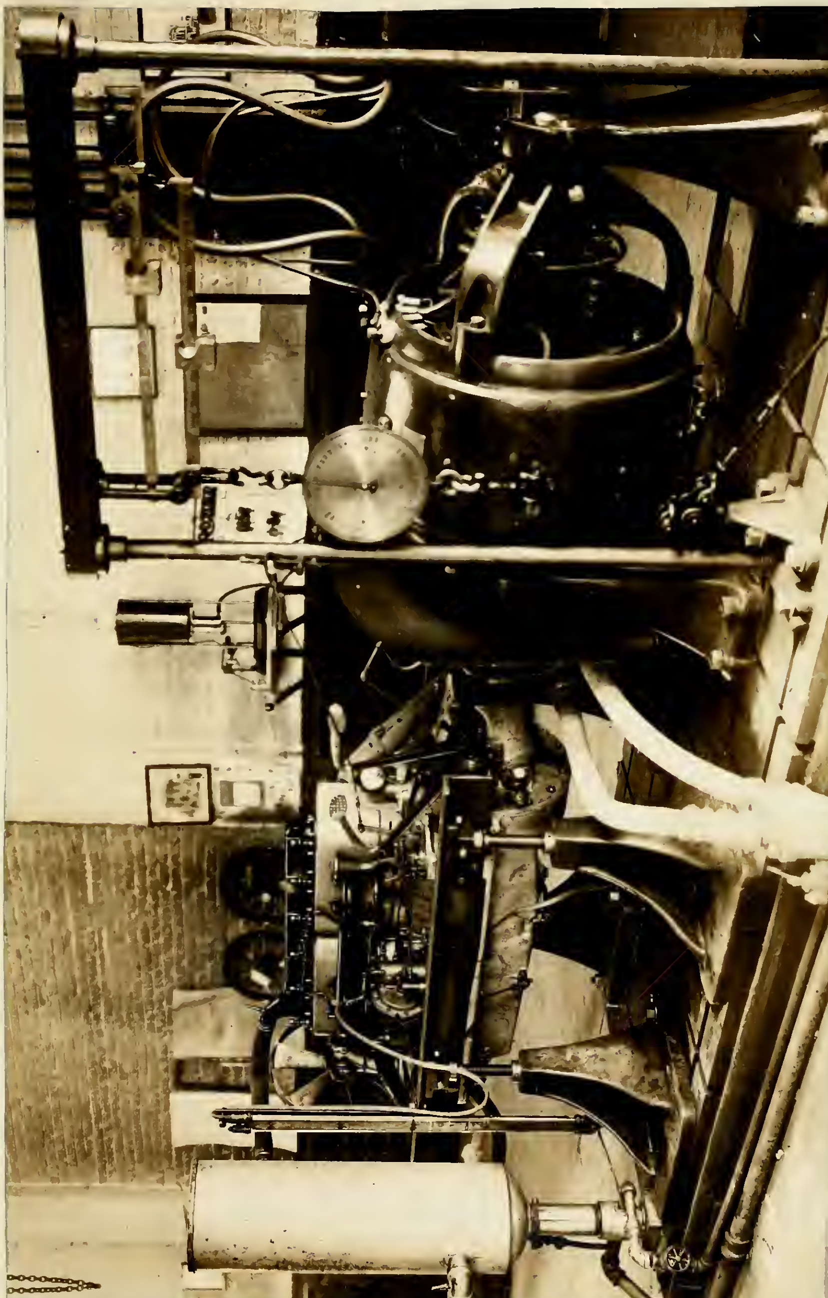

PART I.

A Short Treatise on the Packard 38 Motor and a Description of the Apparatus used in testing it.

INTRODUCTION.

The object of this test is to determine the effect on the economy and power of a Packard "38" Motor by varying the suction pressure. Since the advent of the dynamometer in automobile motor testing, it has been found advisable in order that testing conditions may be uniform, to have all motors tested with full advanced spark and wide open throttle. This has caused some discussion as to effect of having the throttle in different positions, and has led to the investigation mentioned in the first sentence.

The Packard "38" Motor.

The Packard "38" is a six cylinder four cycle L-head motor, the cylinders having a 4 inch bore and 5-1/2 inch stroke, thus giving a bore stroke ratio of 1.375, and a horse power ratio S. A. E. of 38; the cubic displacement in each cylinder is 69.115 cubic inches, and the clearance volume 21.77 cubic inches. The cylinders are cast in blocks of three.

The valves are all on the right side of the motor, the exhaust head also connecting on this side. The inlet manifold is carried on the left side, and is split into three sections, each passing between two of the pairs of cylinders, one through the water jacket to the right side. The manifold connections, which are four in number, bolt to the left side of the cylinder casting and from these connecting points the mixture is distributed to the intake ports.

The inlet manifold has a straight horizontal main section, from which the cylinder

connections pass and a short section at right angles connecting with the carbureter. The manifold is water jacketed along its horizontal length; this together with added heating that the fuel receives in passing through the water jacket spaces in the cylinder, helps the efficiency of the motor considerably.

The exhaust manifold is of the double type known as the Siamese arrangement, in that each block of the three cylinders has a separate passage; that for the rear block is cast integrally with the front header, however, there is a connection between the two as far back as the flange where the exhaust pipe joins.

The lubrication is by a force feed from a gear driven pump located in the crank case. After being strained the oil is forced by the pump through an external pipe up to another strainer mounted at the forward end of the motor. It then flows down to the camshaft through an internal passage within that part of the forward end of the crank case which forms the rear of the timing gear housing.

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Holes drilled in the bearings communicate with the hollow center of the camshaft and as the latter revoles these register with the main lead just mentioned; this applies to the other bearings as well. Leads in the crank case web carry oil down to the crank shaft bearing and then through leads it is brought down to the connecting rod bearings. The connecting rods are also drilled and from here the oil is led to the piston pin bearings through the rods.

The carbureter is of the firm's own design, and manufacture, combining float feed, automatic mixture regulation for all motor speeds and uniform temperature. It has a water jacketed cylindrical mixing chamber, the auxiliary air inlet being automatically regulated for varying speed by a spring controlled poppet valve, the latter being controlled by a small lever which regulates the spring tension for varying atmospheric conditions. In connection with this carbureter is a hydraulic governor, consisting of a diaphragm enclosed in a compartment. The pressure of the water

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The carburetor is of the firm's own design and manufacture, combining float feed, automatic mixture regulation for all motor speeds and uniform temperature. It has a water jacketed cylindrical mixing chamber, the auxiliary air inlet being automatically regulated for varying speed by a spring controlled poppet valve, the latter being controlled by a small lever which regulates the spring tension for varying atmospheric conditions. In connection with the carburetor is a hydraulic governor, consisting of a diaphragm enclosed in a compartment. The pressure of the water

system bears on one side of the diaphragm while the other side of the diaphragm is interconnected with the carbureter throttle, so that when the water pressure is greatest, due to a higher engine speed, the diaphragm is bulged outward and through a rod connection partly closes the throttle, thereby tending to maintain a uniform motor speed. The motor is cooled by positive water circulation through cellular motor cylinder water jackets by a gear driven centrifugal pump; together with a belt driven ball bearing fan.

Ignition, which is entirely independent of the lighting and cranking, is provided by a Bosch duplex system, using a single set of spark plugs. The high tension Bosch duplex magneto sends the secondary current directly to the spark plugs.

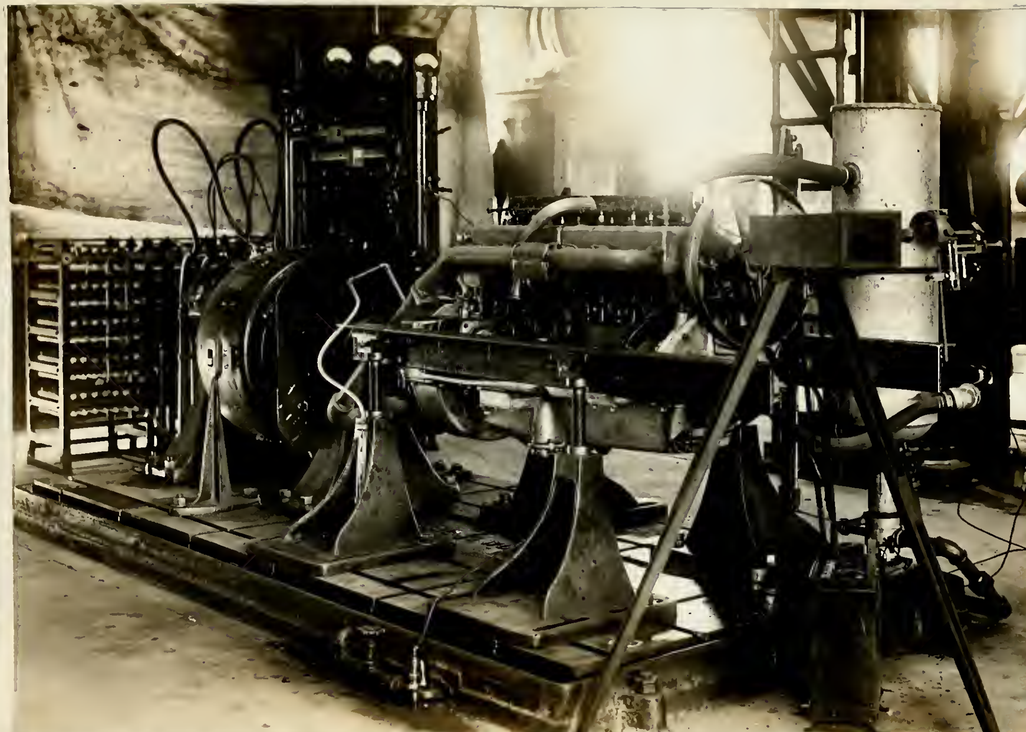

Fig. 2

Description and Operation of the Various Testing Equipment.

The Sprague electro-dynamometer was used in thetesting of the Packard motor. Briefly, it consists of a one-hundred horsepower direct current inter-pole generator mounted on a cast iron bed plate. The torque is taken from knife edges screwed to the frame of the generator and transmitted through a drawbar and spring balance scales to a set of chatillion scales. The length of this arm is equal to 1.315 feet, so that the torque multiplied by the R. P. M. divided by 4000 gives the horse power developed. Ways are cast in the bed plate for holding down motor stands; these stands can be adjusted so as to accomodate any size motor and have the engine lined up with the armature shaft in such a way that a flexible coupling can be inserted between the two. The switchboard is mounted on pipe stands within reach of the scale beam. It contains the control switches, field rheostat circuit breaker, ammeter and voltmeter, for the electro-tachometer. In order to maintain a

steady field flux that will not vary with the speed, the field is separately excited. The drawing at the back of this thesis shows the electrical connections of the apparatus.

The following instructions for operating were sent out with the machine by the Sprague Electric Works.

Instructions for
Operating The Sprague
Electro-Dynamometer
"Preliminary Adjustment."

"The dynamometer should first be balanced at a standstill and before connecting it to the engine to be tested. Care should be taken that the incoming leads to the dynamometer frame do not exert a pull which interferes with the pull of the dynamometer frame on the beam scale. When a balance has been obtained with the beam scale reading zero, connect the engine to be tested."

Starting.

"Leave all the single pole switches open. See that the field rheostat is turned as far as it will go to the full field position. Close the field switch and be sure that there

is a current in the field circuit. Trip the circuit breaker and put both interlocking switches to the right. Close the single pole switches in the upper row one at a time. The machine should start after two or three switches have been closed."

Operation as Motor.

"If it is desired to increase the speed in order to take a friction test at higher speeds than that of starting, continue closing the switches in the top row one at a time. When all of the top switches are in, close the circuit breaker which in turn short circuits the resistances. If speed is to be still further increased, open all the single pole switches and slowly turn the field rheostat handle so as to weaken the field.

PRECAUTION. Do not weaken the field before the circuit breaker has been closed and all single pole switches open."

Operating as Generator.

"Before operating the dynamometer as a generator, see that the field rheostat is

is a current in the field circuit. Trip the circuit breaker and put both interlocking switches to the right. Close the single pole switches in the upper row one at a time. The machine should start after two or three switches have been closed."

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PRECAUTION. Do not weaken the field before the circuit breaker has been closed and all single pole switches open."

Operation as Generator.

"Before operating the dynamometer as a generator, see that the field rheostat is

turned to the full field position and two or three switches in the top row closed. When the engine to be tested has begun to run under its own power, throw the lower transfer switch to the left. The load is now increased by closing the switches in the top row and at the same time supplying more power to the motor being tested. Variation in speed is obtained by the field rheostat."

"To load the dynamometer at speeds below one half of normal speed as stamped on the dynamometer name plate, close three or four switches in the lower row, leaving the switches in the top row closed, and throw the upper half of the transfer switch to the left. The load may now be increased by closing the switches in the lower row one at a time."

"Care should be taken to manipulate the load switches and field rheostat so that the current does not exceed three hundred amperes and the voltage on high speed load does not exceed 250 volts continuous or 300 volts for five minutes. In increasing the load when

running at half the normal speed, if the current rises over three hundred amperes strengthen the field and open a few switches. Do not allow the voltage when running at half of normal speed to exceed 125 volts.

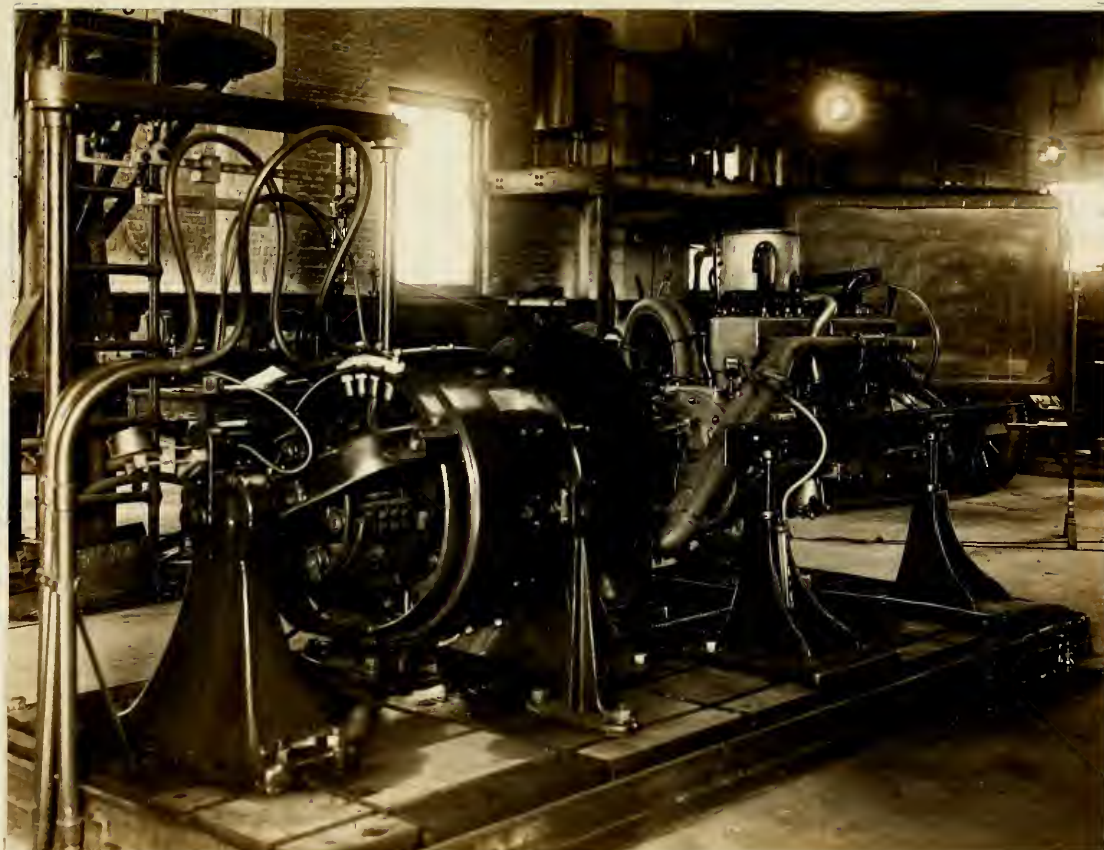


Fig. 3

Gas Consumption.

One of the hardest problems presented was that of obtaining accurate fuel consumption for short runs of two or three minutes each, where the amount of fuel consumed was so small as to make it impossible to ascertain the consumption by simply the difference in weight before and after the run. In order to overcome this a gasoline tank was installed as shown in Figure 1

It consisted of an inner and outer cylinder, the inner one capable of holding about two pounds of gasoline and the outer about twenty five pounds. The stop cocks could be so arranged that both tanks would feed the motor at once or just the small one; the latter was found to be sufficient for any of the runs made in the test. As soon as the small tank became empty the stop cock could be opened and the small tank replenished from the large one, after which the connection could again be closed. By a few small gear wheels a float operated a dial which when calibrated, indicated the

amount of gasoline used; this float also indicated through a tall gauge glass the amount of gas in the large cylinder; after a number of calibrations, it was found that for one complete turn of the dial .280 pounds of fuel would run from the tank. The entire apparatus was mounted upon a scale from which amounts of gasoline used both in the calibration of the tank and the tests of the motor could be fairly accurately verified, due to the fact that when the scale beam reached a definite position points on the beam would come in contact with mercury placed in small cups and in so doing complete an electrical circuit causing a bell to ring. Data relative to the calibration of this tank can be found under preliminary observations page 21. This gasoline tank was placed about ten feet from motor and about six feet from the floor level, the connection being made through two flexible tubes connected by a pipe passing underneath the floor.

Cooling Apparatus.

Due to the fact that the motor as tested had no radiator, the cooling water was supplied from a tank placed at the side of motor, best shown in Figure ▸ . The amount of incoming cold water could be regulated by a valve, while the amount of water pumped by the motor depended of course on the speed of the latter. Data and curves taken on this item are shown later in this thesis, the highest amount taken care of by the pump being nearly 36 gallons per minute at about 1700 R. P. M. The temperature of the inlet and outlet water were taken and in general it was found to be between 100° F. and 150° F.

Manograph.

A manograph or optical gas engine indicator was used in obtaining some of the data. It was driven off the crank shaft and was connected directly to it where the shaft protruded from the front of the motor. Illumination was furnished by a small arc-light focused on the eye piece. It was designed and manufactured by I. Carpentier of Paris, France. This instrument was calibrated with the aid of a compressed air tank of known pressure. The results of this calibration are shown on the manograph cards at the back of this report, while the position of this manograph is best shown in Figure 2 .

The speed counter used was of the simplest type; the counter merely being pushed into the end of dynamometer motor shaft and readings taken for periods of one half minute or minute as the case demanded.

Two mercury manometers were used in this test; one for measuring the pressure at the in-

take manifold and the other placed in the exhaust line, from the front block of cylinders. They were both of the "U" type; the one on the intake manifold being capable of measuring about twenty inches of pressure, while that on the exhaust measured about eight inches pressure. The manometer on the intake manifold was connected by flexible rubber tubing to a small stop-cock which was in turn connected to a small brass pipe brazed on the manifold. The exhaust manometer was simply connected by a curved pipe and flexible tubing, the latter two connected by a small cock.

This concludes the principal apparatus used in this test, such items as the types of thermometers used, watches, etc, are of little consequence in a test of this kind, as it is merely desired to keep things constant for a very short period of time. The maximum time for any run being about three minutes.

PART II.

Observations and Tests made with Sample Calculations leading to Definite Results.

Preliminary Observations.

Introduction.

Before the actual test runs were made on the motor several preliminary observations were necessary; briefly speaking, a determination of the range of ignition was made as well as the valve timing. The gasoline tank and water pump were calibrated and the clearance volume of cylinder No. 1 was determined. The method pursued in making these determinations together with the figures resulting from the latter are shown on the following pages.

Determination of the Range of Ignition.

The spark lever was set to the full retard position, after which the engine was turned over by hand until cylinder number one was at top dead center and on the compression stroke. In this position the cylinder was ready to fire its charge of gas. The cover on the breaker box was disconnected and a thin piece of paper inserted between the platinum points, after which the motor was turned backward or forward

until the points were closed and the paper held securely. The motor was then turned over slowly until the points just released the paper; this was the point of ignition for the retard position of the spark lever. A mark was made on the flywheel opposite the indicator and the distance measured on the flywheel from the mark to the top dead center of the corresponding cylinder. The paper was replaced between the breaker points and the spark lever advanced a trifle. The flywheel was turned back half of a revolution and then brought forward slowly until the points just began to separate. This was the point of ignition for full advance of the spark. A mark was made on the flywheel opposite the indicator as before, and the distance measured from the mark to the top dead center.

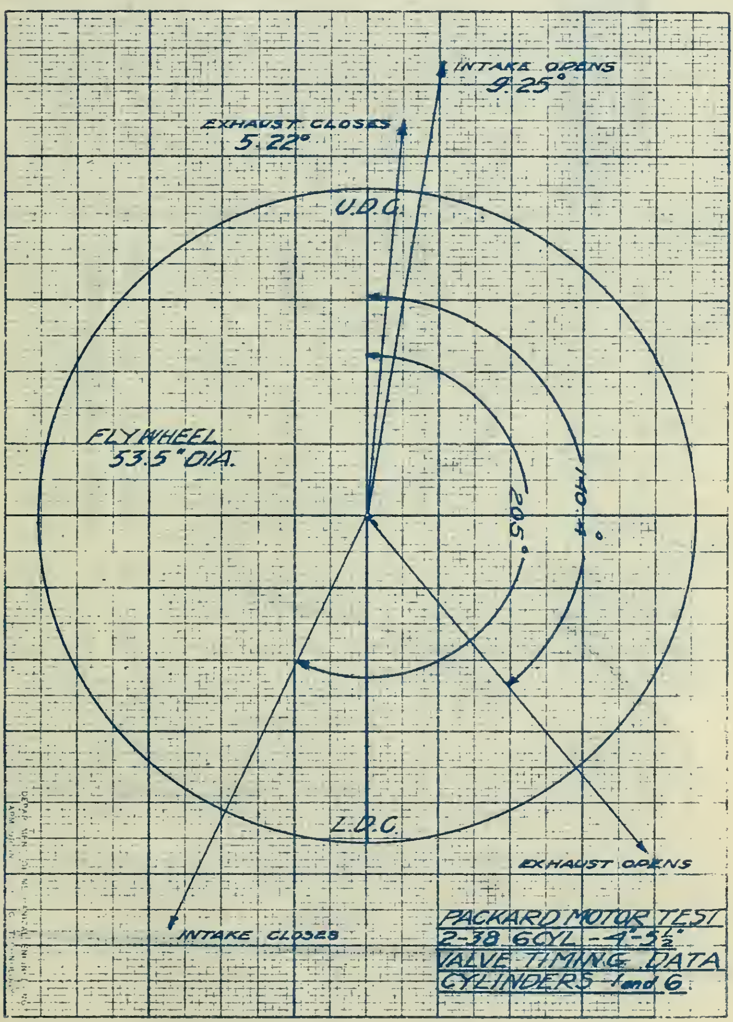
To obtain these results in degrees as was done it was necessary to multiply the distance measured by 360 and divide this by the circumference of the flywheel, the latter being determined by slipping a tape around the outside

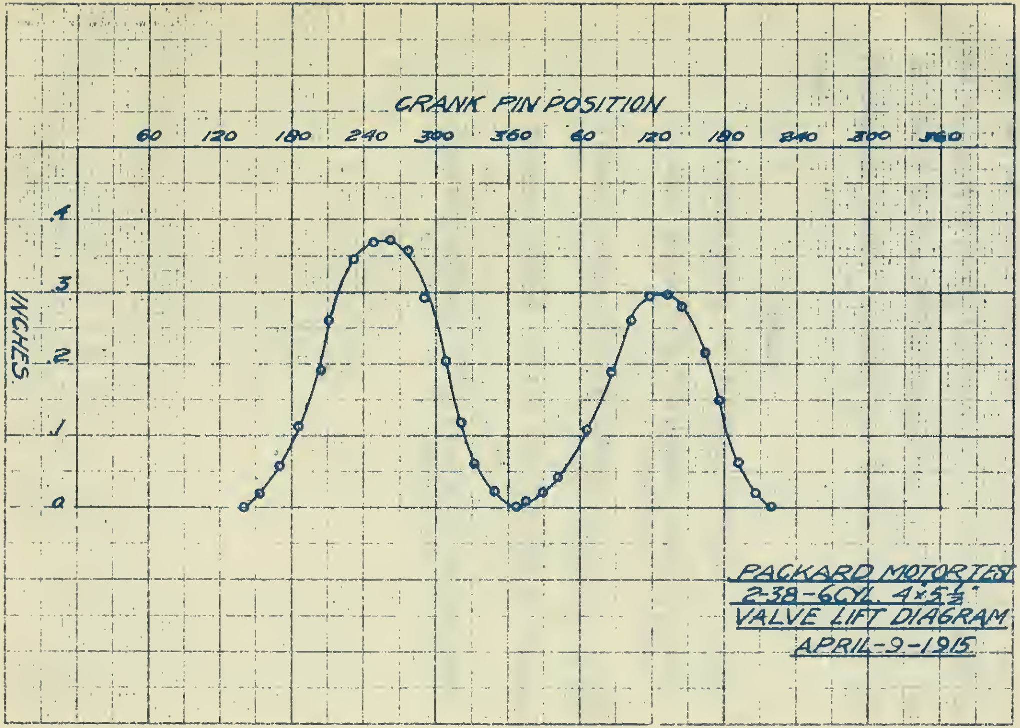
of the flywheel. The spark lever was set at various positions and the points of ignition determined for each position as above.

Valve Timing.

Before the valves were set the clearance was determined. This should be about .004 of an inch on the intake valve and about .005 of an inch on the exhaust valve. The method of setting the clearance was as follows:

A gauge of the proper thickness was inserted between the intake valve stem and the push rod, after which the motor was turned over until the mark "Inlet Valve Opens" on the flywheel appeared opposite the indicator mark. The valve should just begin to open at this point. If the valve should open before the mark on the flywheel and indicator coincide, the length of the push rod can be adjusted. If the valve opens too late, the valve tappets can be adjusted until the right opening is obtained. The engine was then turned over by hand until the stem rested on the low part of


INTAKE OPENS
9.25°
EXHAUST CLOSES
5.22°
U.D.C.
FLYWHEEL
53.5" DIA.
205°
140.4°
L.D.C.
EXHAUST OPENS
INTAKE CLOSES
PACKARD MOTOR TEST
2-38 6CYL - 4"-5½"
VALVE TIMING DATA
CYLINDERS 1 and 6


CRANK PIN POSITION
60
120
180
240
300
360
60
120
180
240
300
360
INCHES.
.4
.3
.2
.1
0
PACKARD MOTOR TEST
2-38-6CYL. 4×5½"
VALVE LIFT DIAGRAM
APRIL-9-1915

the cam at which time the thickness gauge should be extracted from the tappets. If the setting was made properly the gauge will just fill the clearance space between the valve stem and push rod.

Data.

Circumference of Flywheel 53-1/2 inches

Intake opens 1-3/8 inches. equals 9.25° degrees L.U.D.C.

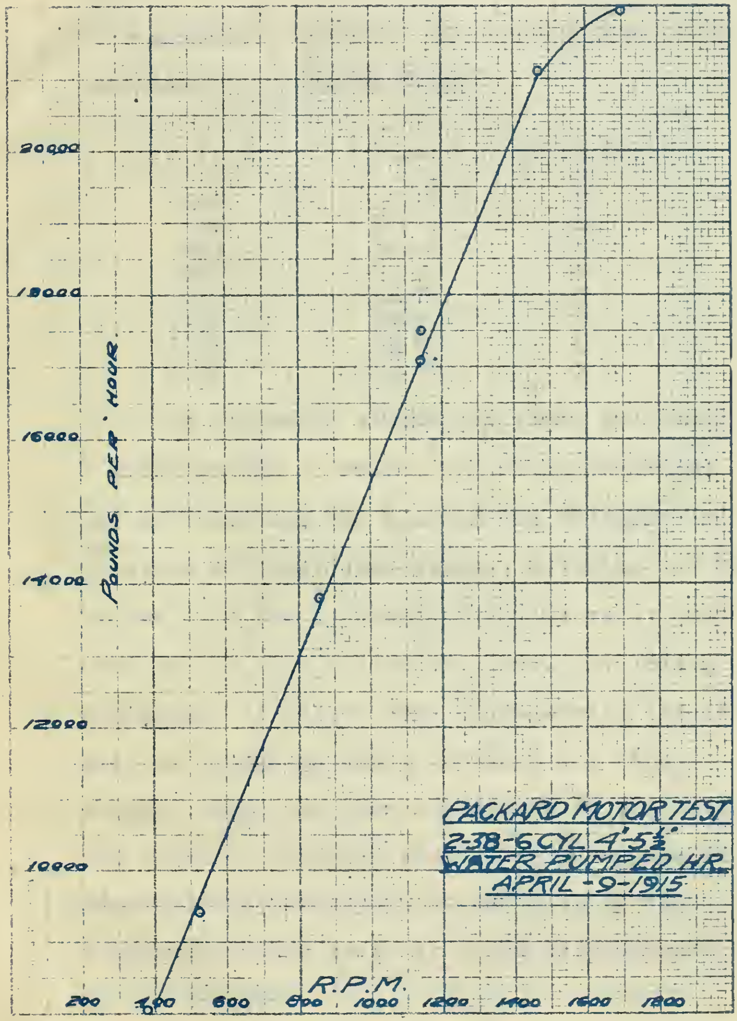
Intake closes 3-3/4 inches L.L.D.C. equals 205 degrees L.U.D.C.

Exhaust opens 19-1/2 equals 140.4° degrees L. U. D. C.

Exhaust closes 7/8, equals 5.22 degrees L.U.D.C.

The same scheme was carried out for the exhaust valve after the clearance had been set, the motor was turned over until the intake valve on any particular cylinder began to open. The distance was measured on the flywheel from top dead center to the mark made as explained above. The motor was again turned over until the exhaust valve began to open and the distance again measured from the mark to the lower dead center. The same procedure was gone through in determining the closing points of the intake and exhaust valves. The results appear below.

The determination of the amount of cooling water pumped at different speeds was made as follows; a three way valve was placed in the outlet line leading from the motor to the cooling water tank. The engine was then run at different speeds and the water coming from the motor was allowed to flow for five seconds into a receptacle placed on weighing scales. In this way the amount of water pumped per minute for each speed was determined by multiplying the



20000
18000
16000
14000
12000
10000
POUNDS PER HOUR.
R.P.M.
200
400
600
800
1000
1200
1400
1600
1800
PACKARD MOTOR TEST
2-38-6 CYL 4"-5½"
WATER PUMPED HR.
APRIL-9-1915

weight of water flowing into the receptacle for five seconds. The data and curve for this determination are shown below.

R.P. M.	Lbs.	Time sec.
366	11.25	5
532	13.	5
860	19.25	5
1004	21.5	5
1178	23.75	5
1466	29.5	5
1532	31.5	5
1710	30.5	5

The clearance volume was found by taking a known weight of water, and after removing the cylinder cap and placing the cylinder in question on upper dead center, allowing the water to run into the cylinder until the water just came to the head of the cylinder. By rating the weight of water used, and assuming the density as unity the cubic contents was easily found. Since the bore and stroke of the motor are known the percent clearance volume can be determined by multiplying the ratio of the clearance volume over the cubic displacement by one hundred.

Some difficulty was found in calibrating

the gasoline tank due to the fact that the small brass gear wheels operating the dial pointer were not smoothly finished and caused the pointer on the dial to stick, thus giving incorrect readings. After this defect had been adjusted the work of calibrating the tank was as described below. The tank was first filled with gasoline and its weight noted. The scale bob was then placed one pound under this weight and the stop cock from the small tank opened and the gasoline allowed to run out. Due to the fact that the scale was electrically connected, a bell was rung the instant the amount of gasoline running from the tank had reached one pound. During this period the number of turns and fraction thereof that the pointer made were noted. These determinations were made a number of times, for different weights of gasoline. From this data the amount of gasoline used for each turn of the pointer could be calculated by dividing the weight of gasoline allowed to run out of the tank, by the number of turns made. From the data obtained it was found that .28 of a

the gasoline used and the fact that the small bevel gear wheels connecting the dial shafts were not smoothly finished and caused the pointer on the dial to stick, thus giving incorrect readings. After this defect had been adjusted the work of calibrating the tank was as described below. The tank was first filled with gasoline and its valve closed. The scale pan was then loaded one pound under this weight and the valve that from the small tank opened and the gasoline allowed to run out. When the first mark was, the scale was electrically connected, a bell was rung the instant one pound of gasoline running from the tank had lowered the pointer. During this period the number of turns and fractions thereof that the pointer made was noted. These determinations were made a number of times, the different weights of gasoline. From this data the amount of gasoline used for each turn of the pointer could be calculated by dividing the weight of gasoline allowed to run out of the tank, by the number of turns made. From the data obtained it was found that one turn of a

pound of gasoline ran from the tank for each revolution of the pointer. This result may not be absolutely correct, but it is the average of a great many calibrations and therefore may be considered a value which will give fairly accurate results as far as the actual economy of the engine is concerned, and as far as relative economy is concerned between the different throttle pressures it may be considered correct. The latter economy was the one desired in the test.

Calibration.

Gasoline Tank.

Wt. Lbs.	Turns.	Lbs. Turn.
1	3.69	.272
1	3.56	.281
1	3.54	.282
1	3.63	.275
1	3.70	.270
2	7.15	.280
2	7.13	.281
2	7.22	.278
2	7.17	.279
2	7.10	.281

Average of the total is equal .28 pounds per turn of the dial.

Engine Tests.

The tests of the motor are listed under two general heads, namely: Power and Economy Runs, and Friction Horsepower Runs. The former are eight in number and the latter seven. Besides these two sets of data compression runs for each suction and a number of speeds were made, the curves, manograph cards and data for each of these runs being shown at the back of the thesis.

The tests at the different suctions were run at speeds varying from 300 R. P. M. to 2000 R. P. M., generally five different speeds were taken together with the other items shown on the log sheets. The gasoline consumption was obtained as described under preliminary observation, in almost all cases three readings being obtained in order to check the results. The same might be said of R. P. M. readings, which were generally two in number each being made for 30 seconds.

The friction horsepower runs were made as

described from speeds of 300 R. P. M. to 1000 R. P. M., and the curve for the horse power thereafter assumed. The reader is referred to the discussion of results and curves for a more complete analysis of the results of the test.

The method used in calculating the different items of the log sheet can best be shown by an actual computation. Run No. 1 with wide open throttle will be carried through as a sample computation.

The log sheet shows that the average time required for 664 revolutions of the motor was one minute.

The torque was 173 lbs, which gives the horse power developed as 173 X 664 ÷ 4000, equals 28.8.

The torque in ft. lbs is equal to the torque multiplied by the length of the arm in ft., which gives 173 X 1.315 equals 227.5.

The friction horsepower as taken from the friction curve is equal to 4.0.

The indicated horsepower then is the sum of the developed or the brake horse power plus

the friction horsepower or 28.8 plus 4.0, equals 32.8 I. H. P.

The Motor used .56 lbs. of gasoline in 88 seconds, or 22.9 lbs. per hour, thus .56 X 3600 equals 22.9 lbs per hour.

The gasoline consumption per B. H. P. is 22.9 ÷ 28.8 equals .824 lbs.

The density of the gasoline in degrees Baume was found to be .60.

From the equation for low testing value of gasoline, namely:

B. T. U. per lb. equals 17030 plus 40 (B-10).

Where (B) is the Baume reading, the heating value of the gasoline was found to be 19030 B. T. U. per lb.

The B. T. U. supplied per hour to the motor is equal to

19030 X 22.9 equals 436500 B. T. U.

The heat equivalent of one horsepower is 2545 B. T. U. per hour. Then the percent of the total heat which is utilized as B. H. P. is equal to $\frac{2545 \times 28.8}{436500} \times 100$ equals 16.8%.

From the calibration curve of the water pump we find that it circulates 11250 lbs of water per hour at the above speed.

The temperature difference was equal to 9 degrees Fahrenheit, hence the heat lost to cooling water is equal to 9 X 11250 equals 101250 B. T. U. and the percentage of heat lost to the jacket water is equal to

$$\frac{101250 \times 100}{436500} \text{ equals } 26.1$$

Of the total heat supplied 45. 1% has been accounted for, leaving 57.1% lost to radiation, exhaust, etc.

Discussion of Results
from Motor Tests.

The data and curves resulting from the tests of the motor show clearly that a distinct relation exists between the suction pressure and the power and economy.

The economy curves show the following facts, that the gasoline consumption per hour decreases with the mercury depression, but at the same time the actual gasoline consumption per B. H. P. hour increases with the mercury depression.

In regard to the power, it can be said that the torque, B. H. P. and I. H. P. decrease an appreciable amount for each increase in the intake depression. The best B. H. P. obtained during the entire test was sixty three, the latter remaining almost constant from 1700 R. P. M. to 2000 R. P. M.

The M. E. P. - R. P. M. curves show the same tendency as the H. P. curves, namely, that of decreasing as the depression increases, the maximum M. E. P. for each suction being

reached from the speeds of 600 R. P. M. to 800 R. P. M.

The mechanical efficiency curves are especially interesting, due to the wide range of value obtained, the wide open throttle run showing an efficiency of 73% at 1800 R. P. M. and 89% at 400 R. P. M., while the 16inch suction shows values ranging from 10% to 63% for the same speeds as above.

In the matter of efficiency, the thermal, heat lost in cooling water and the heat lost in the exhaust evidently do not follow any direct low, but are influenced by outside conditions which cannot be altered and the result therefore could not be discussed with any degree of satisfaction, except to say that the thermal efficiency and heat lost in the exhaust are of values generally accepted as correct in motor practice.

From the manograph cards shown, one common fault is at once noticeable, that of slow burning of the gases. This is, however, to be expected from the type of motor used, as it is considered an inherent fault of the "L" head

type of motor.

From the compression cards it can be seen that the compression increases as the suction depression decreases, and also that the general form of the curve drawn through the highest points of the compression lines follows very closely the torque curves spoken of on a former page.

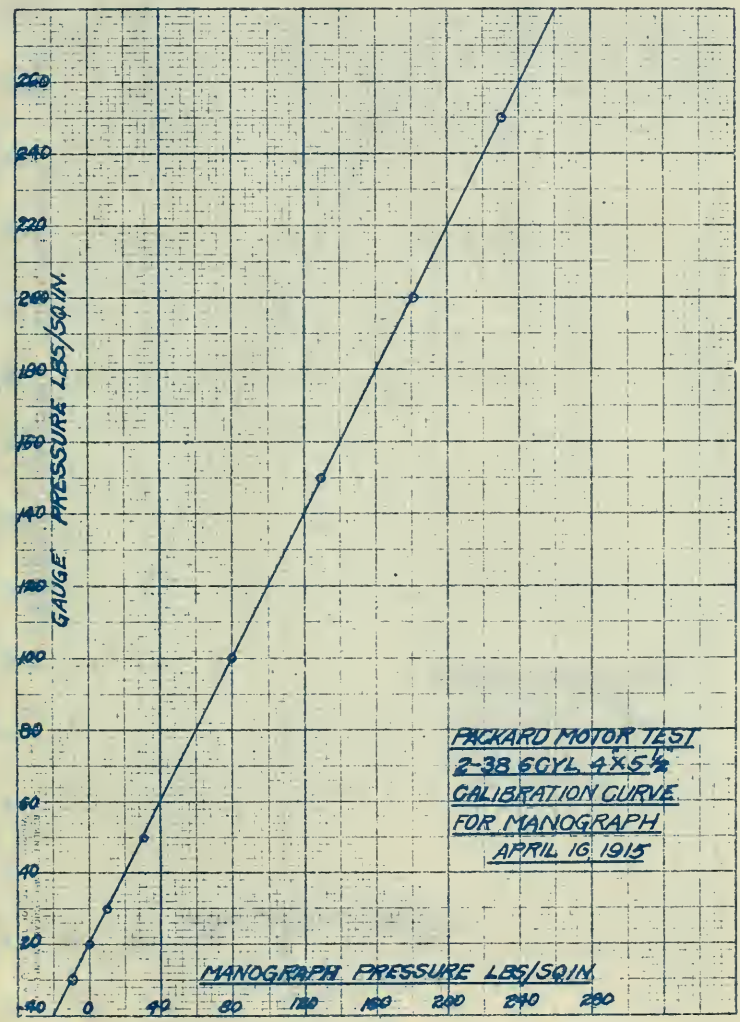
In conclusion the reader is referred to the numerous curves and log sheets appearing at the back of this thesis, and which show more clearly than can be described not only the little individual characteristics of each suction and speed, but also the relation which exists between the suction depression and the power and economy.

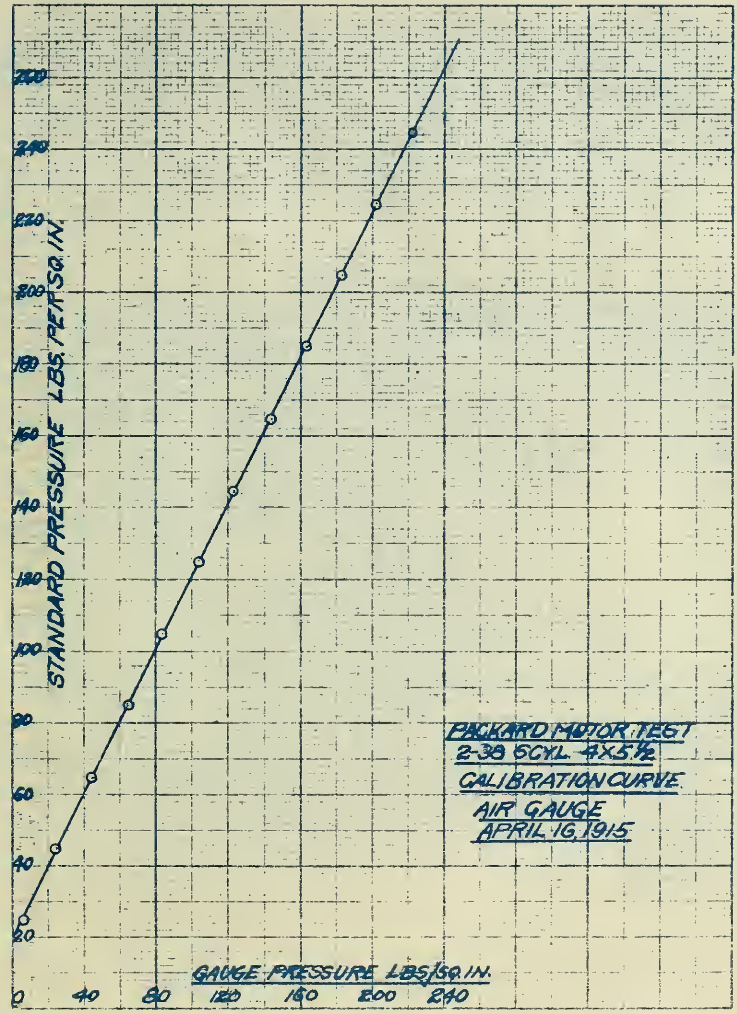
PART III.

Data sheets.

Curves.

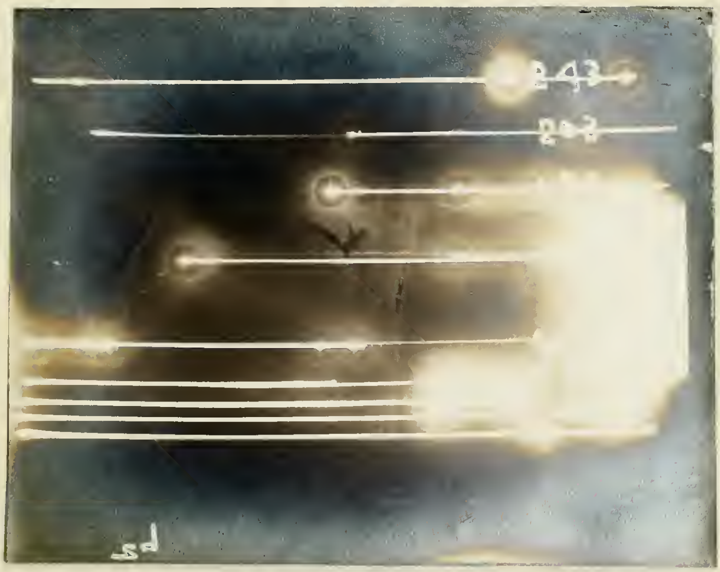
Manograph Cards.


GAUGE PRESSURE LBS/SQ.IN.
MANOGRAPH PRESSURE LBS/SQ.IN.
PACKARD MOTOR TEST
2-38 6CYL 4 X 5 1/2
CALIBRATION CURVE
FOR MANOGRAPH
APRIL 16, 1915


PACKARD MOTOR TEST
2-38 6CYL. 4X5½
CALIBRATION CURVE
AIR GAUGE
APRIL 16, 1915
STANDARD PRESSURE LBS. PER SQ. IN.
GAUGE PRESSURE LBS/SQ. IN.
0
40
80
120
160
200
240
20
40
60
80
100
120
140
160
180
200
220
240
260

Calibration Card

Pressure
10
20
30
50
65
100
150
203
243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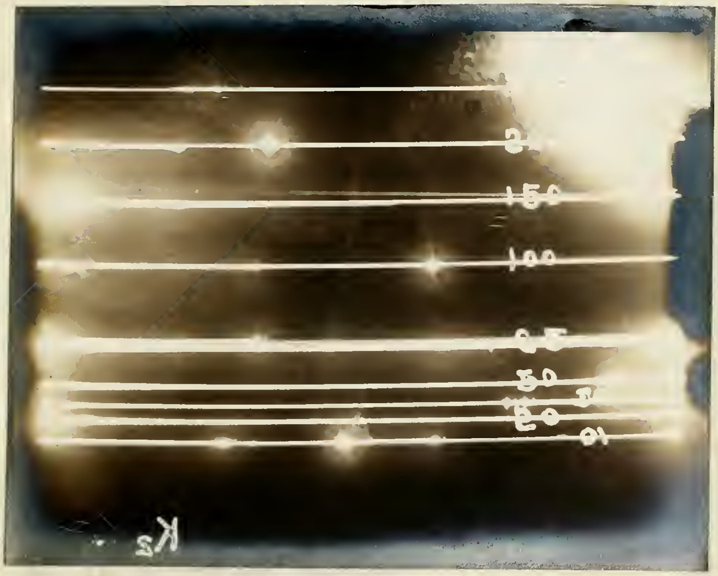

150
100

Calibration Card

Pressure
10
20
30
50
65
100
150
203
243

Index to Data Sheets
and Curves.

Data sheets
Power and Economy Runs.

Friction Horse Power Runs.

Curves.

Curves (cont).

PACKARD MOTOR TEST
OBJECT: POWER & ECONOMY
SUCTION - WIDE OPEN THROTTLE
TEST NO. 1

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 7, 1915
BAR. 29.40 IN. HG.
TEMP. 65 DEG. F.
GASOLINE 60° B AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F.		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT ABS. JACKET WATER %	HEAT IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	664	173	28.8	4.0	32.8	87.7	82.8	111	120	½	—	11250	101250	22.9	.824	16.8	26.1	57.1	24
2	992	175	43.5	8.5	52.0	83.7	83.8	118	126	1⅛	—	15250	122000	35.6	.819	16.3	18.1	65.6	28
3	1361	157.5	53.6	14.9	68.5	78.2	75.3	115	122	1⅝	—	20700	145000	39.3	.732	18.2	19.5	62.3	36
4	1513	156.5	59.3	17.5	76.8	77.2	74.8	110	117	1¾	—	21200	148400	54.2	.746	16.4	16.1	67.5	39
5	1747	139	60.7	23.0	83.7	72.5	66.4	109	117	2⅛	—	22000	176000	48.3	.797	16.3	18.5	65.2	40
6	1940	119	57.7	28.0	85.7	67.3	56.8	109	116	2¼	—	22000	154000	50.0	.867	14.2	15.0	70.8	40

PACKARD MOTOR TEST

OBJECT: POWER
SUCTION - WIDE OPEN THROTTLE
TEST NO. 15

MOTOR 2-38
6CYL. 4" X 5½"
NO. 53554

DATE: APRIL 16, 1915
BAR. 29.48 IN. HG.
TEMP. 68 DEG. F.
GASOLINE 60°B AT 67°F.

RUN NO	R.P.M	TORQ.	B.H.P	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F		JACKET WATER		PRESSURES IN HG							POS. SPARK ADV
								INLET	OUTLET	LBS. PER HR.	B.T.U. ABS. HR	INTAKE	EXH.						
1	641	174	27.9	4.0	31.9	87.5	83.2	94	101	11000	77000	½	⅜						30
2	809	175	35.8	6.0	41.8	85.7	84.7	99.5	109.5	13000	130000	13/16	11/16						32.5
3	1236	162	50	12.5	62.5	80	77.4	109.5	116.5	18150	121000	1⅜	1						34
4	1400	162	56.8	15.5	72.3	78.6	77.5	94	102	20200	161600	1 13/16	1⅜						42
5	1204	167.5	50.5	12.0	62.5	80.7	80.1	92	101	17800	160200	1⅝	1⅛						39
6	1554	159.5	61.9	18.5	80.4	77	76.1	102	108	21500	129000	1 15/16	2 3/16						43
7	1620	153.3	62.1	20.0	82.1	75.6	73.2	108	116	21800	174400	1⅞	2 7/16						45
8	1758	142	62.5	23.0	85.5	73	67.8	117	125	22000	176000	1 15/16	2¾						45
9	1842	134.5	62	25.1	87.0	71.3	64.3	118	128	22000	220000	1⅞	2⅞						45
10	1940	129.5	62.8	28.0	90.8	64.2	61.9	97	106	22000	198000	1⅞	3⅜						45

PACKARD MOTOR TEST
OBJECT: POWER & ECONOMY
SUCTION 2" HG.
TEST NO. 2

MOTOR 2-38
6 CYL 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65 DEG. F.
GASOLINE 60° B AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F.		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT ABS. IN JACKET WATER %	HEAT ABS. IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	628	169	26.5	4.0	30.5	86.8	80.6	106	113.5	2	½	10900	81750	18.61	.703	19.0	23.1	57.9	28°
2	818	170.5	34.86	5.5	40.36	86.5	81.5	120	130.3	2	1 3/16	13200	132000	23.44	.67	19.9	29.6	50.6	32°
3	1418	158.5	56.2	16.5	72.7	77.3	75.7	118	127.3	2	1½	20500	184500	40.42	.718	18.66	24.1	57.24	34°
4	1694	148.5	62.9	23.0	85.9	73.2	70.9	104	113.3	2	3	22000	198000	46.8	.744	18.0	22.25	59.8	40°
5																			
6																			
7																			
8																			
9																			

PACKARD MOTOR TEST

OBJECT: POWER & ECONOMY
SUCTION 3" HG.
TEST NO. 3

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65 DEG. F.
GASOLINE 60° B AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL WATER DEG. F.		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT ABS. IN JACKET WATER %	HEAT ABS. IN EXH. RAD ETC %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	672	162.5	27.3	5.0	32.3	84.5	77.6	87.3	97.3	3	½	11350	113500	14.18	.52	18.8	42.1	39.1	32
2	894	162	36.4	8.0	44.4	82	77.8	113	120.2	3	1 3/16	14100	98700	23.8	.654	20.5	21.7	57.8	34
3	1228	158	47.6	14.0	61.6	77.3	74	118.5	127.5	3	1½	18150	63350	33.6	.707	18.95	25.5	55.5	38
4	1526	149	56.8	20.5	77.3	73.5	71.2	115.3	124.8	3	1 7/8	21400	203300	38.2	.672	19.9	27.9	52.2	40
5	1739	140.5	61.0	25.5	86.5	70.6	67	108	117	3	2 7/8	22000	198000	43.2	.708	18.9	24.1	570	40

PACKARD MOTOR TEST
OBJECT: POWER & ECONOMY
SUCTION 6" HG.
TEST NO. 4

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65 DEG. F.
GASOLINE 60°B AT 67°F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F.		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT ABS. IN JACKET WATER %	HEAT LOST IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P.HR.				
1	601	130.3	19.58	4.0	23.58	83	62.2	91.2	96.1	6	½	10400	52000	17.28	.882	14.7	15.4	69.9	34
2	955	131	30.1	10.0	40.1	75	60.2	102	115	6	¾	14800	192400	21.9	.70	18.3	46.2	35.5	40
3	1378	124.5	42.9	18.5	61.4	70	59.2	107.5	115.2	6	1⅛	19900	159200	29.2	.68	19.7	28.7	51.6	40
4	1614	110.5	44.58	25.5	70.1	63.8	52.7	108.7	117	6	2¼	21700	195300	33.6	.754	17.7	30.5	51.7	40
5	1789	101.5	45.35	30.5	75.85	60.2	48.4	114	124	6	3	22000	220000	33.98	.75	17.85	34.0	48.2	40

PACKARD MOTOR TEST

OBJECT: POWER & ECONOMY
SUCTION 10" HG.
TEST NO. 5

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65 DEG. F.
GASOLINE 60° B. AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P.	TEMP. COOL. WATER DEG. F.		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT ABS. JACKET WATER %	HEAT IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	494	92	11.36	3.5	14.86	76.5	43.8	104	113	10	5/16	9300	83700	10.8	.95	14.1	40.8	45.2	40
2	947	94	22.3	9.5	31.8	70.1	44.9	113	127	10	1/2	14750	206500	17.46	.785	17.1	62.4	20.5	40
3	1156	90	26.0	13.0	39.0	66.7	42.9	94	101	10	11/16	17100	119700	20.8	.80	16.9	30.1	53.1	40
4	1445	78.5	28.36	19.0	47.36	60.0	37.4	107	113	10	1 5/16	20800	124800	24.3	.855	15.6	27.0	57.4	40
5	1796	70	31.43	29.0	60.43	52.1	33.4	120	128	10	1 11/16	22000	176000	29.7	.943	14.2	31.2	54.6	40

PACKARD MOTOR TEST
OBJECT: POWER & ECONOMY
SUCTION 14" HG.
TEST NO. 6

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65° DEG. F.
GASOLINE 60° B AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F.		PRESSURES IN HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT IN JACKET WATER %	HEAT IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	572	64.5	9.22	4.5	13.72	67.1	30.8	115	122	14	3/32	10100	70700	10.87	1.18	11.33	34.2	54.5	40
2	772	61.0	11.75	7.0	18.75	62.6	29.1	118	126	14	5/16	12600	101000	11.66	.98	13.55	45.0	41.5	40
3	1082	44.5	12.01	12.0	24.01	50.0	21.2	102	109	14	1/4	16350	114500	14.94	1.24	10.74	40.2	49.1	40
4	1322	40.0	13.22	17.0	30.22	43.8	19.1	96	103	14	11/32	19500	136500	18.0	1.37	9.51	39.8	50.7	40
5	1609	32.5	13.1	23.5	36.6	35.5	15.6	119	123	14	9/16	21200	84800	19.5	1.48	9.04	22.8	68.1	40
6	1794	9.5	4.26	29.0	33.26	12.8	4.53	123	133	14	9/16	22000	220,000	18.36	4.3	3.09	62.9	34.0	40

PACKARD MOTOR TEST
OBJECT: POWER & ECONOMY
SUCTION 16" HG.
TEST NC. 7

MOTOR 2-38
6 CYL. 4" X 5½"
NO. 53554

DATE: APRIL 9, 1915
BAR. 29.40 IN. HG.
TEMP. 65° DEG. F.
GASOLINE 60° B AT 67° F.

RUN NO.	R.P.M.	TORQ.	B.H.P.	F.H.P.	B.H.P. + F.H.P.	M.E.	M.E.P. NET	TEMP. COOL. WATER DEG. F		PRESSURES IN. HG.		JACKET WATER		GAS CONSUMPTION		THER. EFF. %	HEAT IN JACKET WATER %	HEAT IN EXH. RAD. ETC. %	POS. SPARK ADV.
								INLET	OUTLET	INTAKE	EXHAUST	LBS. PER HR.	B.T.U. ABS. PER HR.	LBS. PER HR.	LBS. PER B.H.P. HR.				
1	344	47.5	4.08	2.5	6.58	62	227	113	120	16	3/32	8000	56000	9.72	2.43	5.6	30.2	64.2	40
2	826	45.5	9.39	9.0	18.4	51	217	101	106	16	1/8	13350	66750	11.78	1.25	10.7	29.8	59.6	40
3	1053	38.5	10.13	13.5	23.6	42.8	184	114	119	16	1/8	16000	90000	14.04	1.37	9.7	33.7	56.6	40
4	1219	32.5	9.9	17.0	26.9	36.8	15.5	116	122	16	3/16	18000	108000	15.84	1.60	8.4	35.8	55.8	40
5	1514	19.3	7.3	24.0	31.3	23.3	92	114	120	16	1/2	21200	127200	20.66	2.83	4.7	32.4	52.8	40
6	1666	10.5	4.37	27.5	31.87	13.7	5.02	115	121	16	9/16	21900	131400	20.16	4.38	2.9	34.2	62.9	40

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4-14-15

SUCTION - WIDE OPEN THROTTLE TEMP. 65 °F

TEST NO. 8 BAR. 29.4 "HG.

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F	
					INLET	OUTLET
1	263	13.5	.888	3/16	123	125
2	351	14.8	1.30	1/4	123	124
3	470	17.5	2.06	3/8	118	119
4	570	21.0	2.99	3/8	116	117
5	694	25.25	4.38	7/16	116	117
6	810	29.3	5.93	1/2	116	117
7	974	36.0	8.76	5/8	116	117

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4-14-15

SUCTION- " TEMP. 65°F.

TEST NO. 9 BAR. 29.4" HG.

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F.	
					INLET	OUTLET
1	260	16.5	1.07	2	115	116
2	386	18.0	1.66	2	114	115
3	449	19.5	2.19	2	114	115
4	565	22.5	3.18	2	114	115
5	663	25.3	4.18	2	113	114
6	773	28.5	5.51	2	113	114
7	912	34.0	7.75	2	113	115
8	980	37.0	9.06	2	114	115
9	1008	38.0	9.43	2	115	117

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4-14-15

SUCTION - 3" TEMP. 65 °F

TEST NO. 10 BAR. 29.4" HG

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE	TEMP. COOLING WATER DEG. F.	
					INLET	OUTLET
1	268	17.25	1.16	3	115	116
2	364	18.25	1.66	3	114	115
3	464	20.25	2.35	3	114	115
4	570	23.5	3.35	3	113	114
5	700	27.5	4.82	3	113	114
6	826	31.5	6.51	3	114	115
7	886	34.5	7.64	3	114	115
8	988	37.75	9.33	3	114	115

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4-14-15

SUCTION - 6" TEMP. 65 °F

TEST NO. 11 BAR. 29.4" HG.

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F INLET	OUTLET
1	306	18.5	1.42	6	115	116
2	376	20.25	1.9	6	115	116
3	504	23.25	2.17	6	114	115
4	618	26.5	4.1	6	114	115
5	726	30.0	5.44	6	114	115
6	854	33.75	7.2	6	114	115
7	930	38.75	9.01	6	114	115

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4·14·15

SUCTION - 10" TEMP. 65°F.

TEST NO. 12 BAR. 29.4" HG.

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F. INLET	OUTLET
1	252	20.25	1.28	10	115	116
2	350	23.5	2.06	10	115	116
3	444	26.0	2.89	10	114	115
4	596	29.5	4.4	10	114	115
5	710	33.0	5.86	10	114	115
6	820	36.25	7.43	10	114	115
7	958	44.75	10.0	10	114	115

PACKARD MOTOR TEST

OBJECT: FRICTION H.P. DATE 4-14-15

SUCTION-14" TEMP. 65°F.

TEST NO. 13 BAR. 29.4"HG.

RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F.	
					INLET	OUTLET
1	268	23.0	1.54	14	114	115
2	354	25.6	2.27	14	114	115
3	460	29.0	3.34	14	113	114
4	586	32.5	4.76	14	107	108
5	734	36.75	6.75	14	108	109
6	830	40.5	8.41	14	108	109

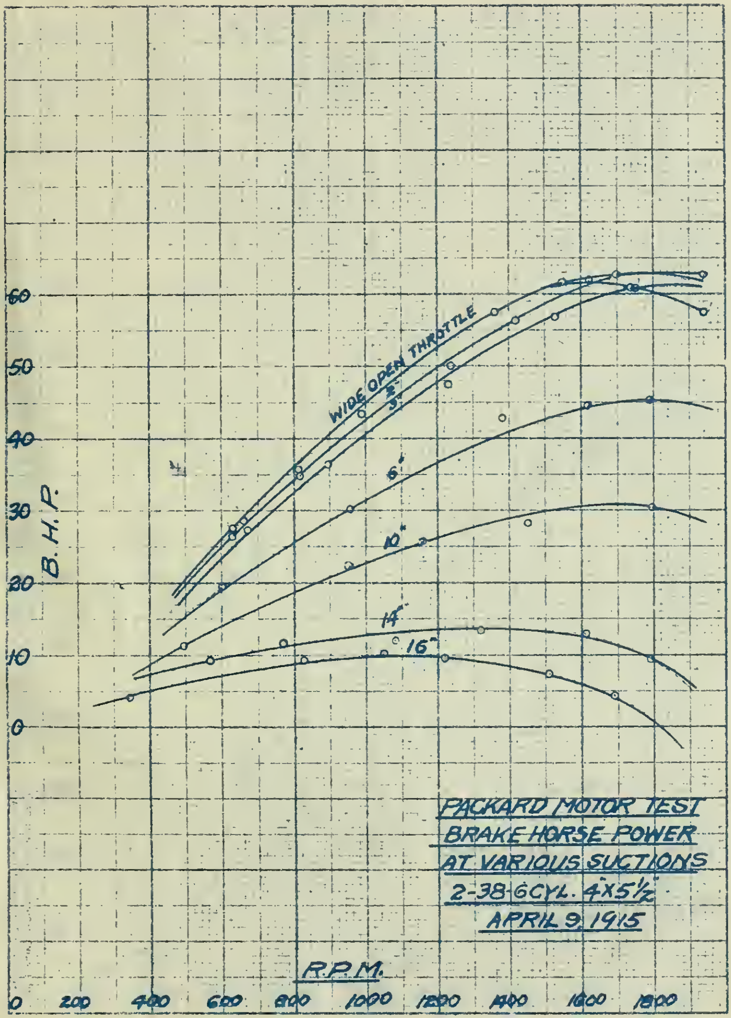
PACKARD MOTOR TEST

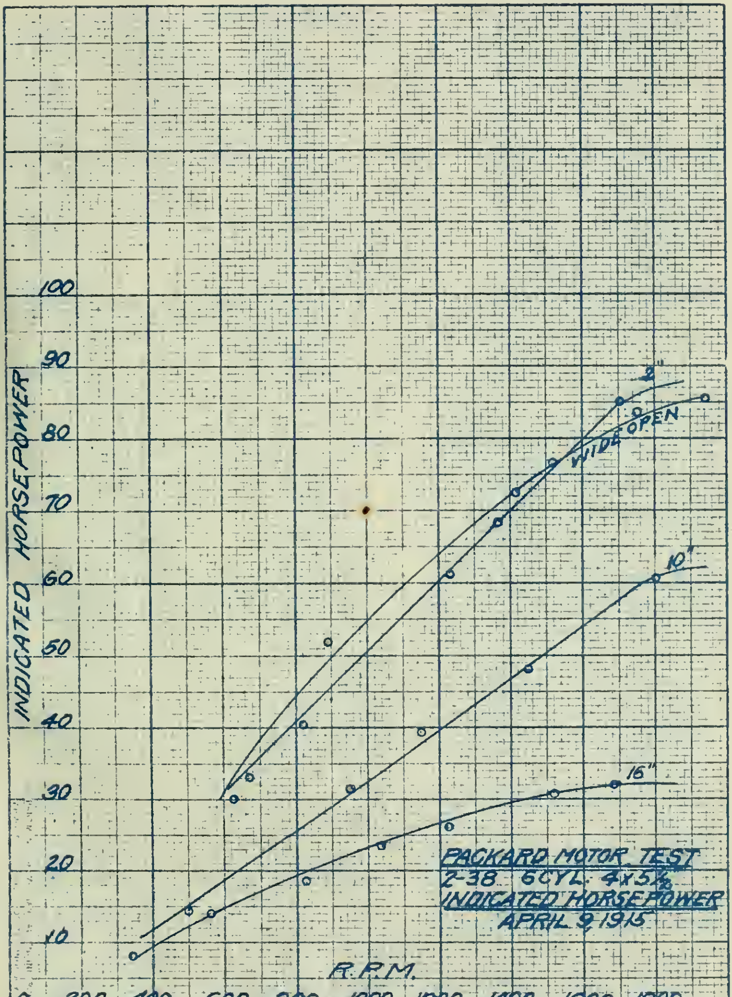
OBJECT: FRICTION H.P. DATE 4-14-15

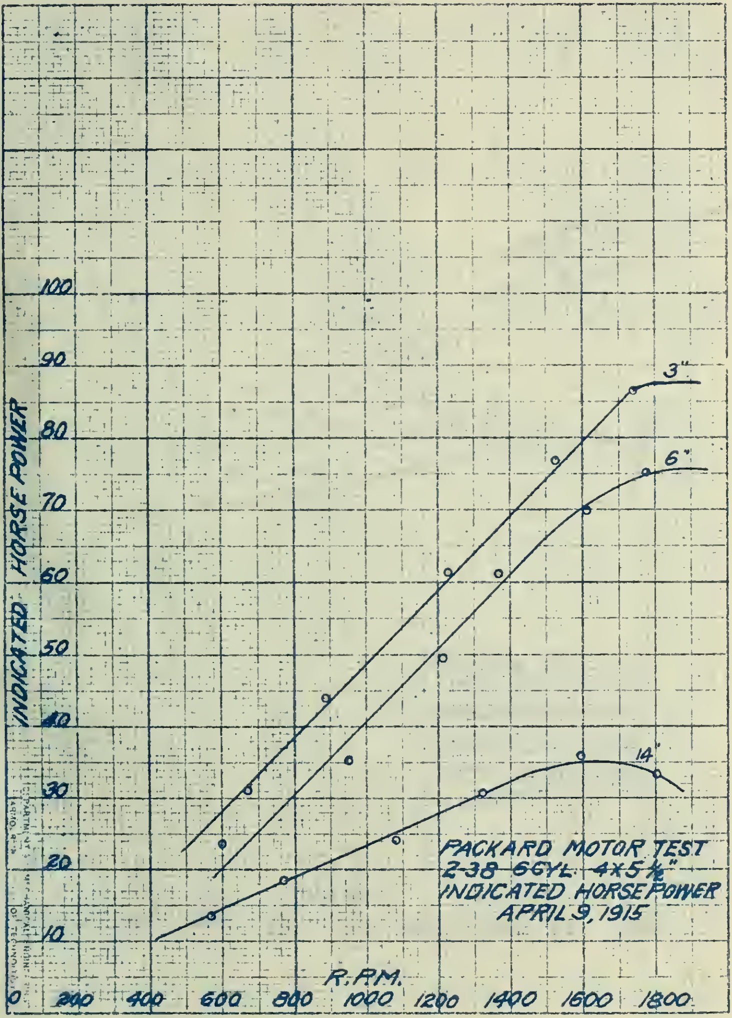
SUCTION 16" TEMP. 65°F

TEST NO. 14 BAR. 29.4 HG.

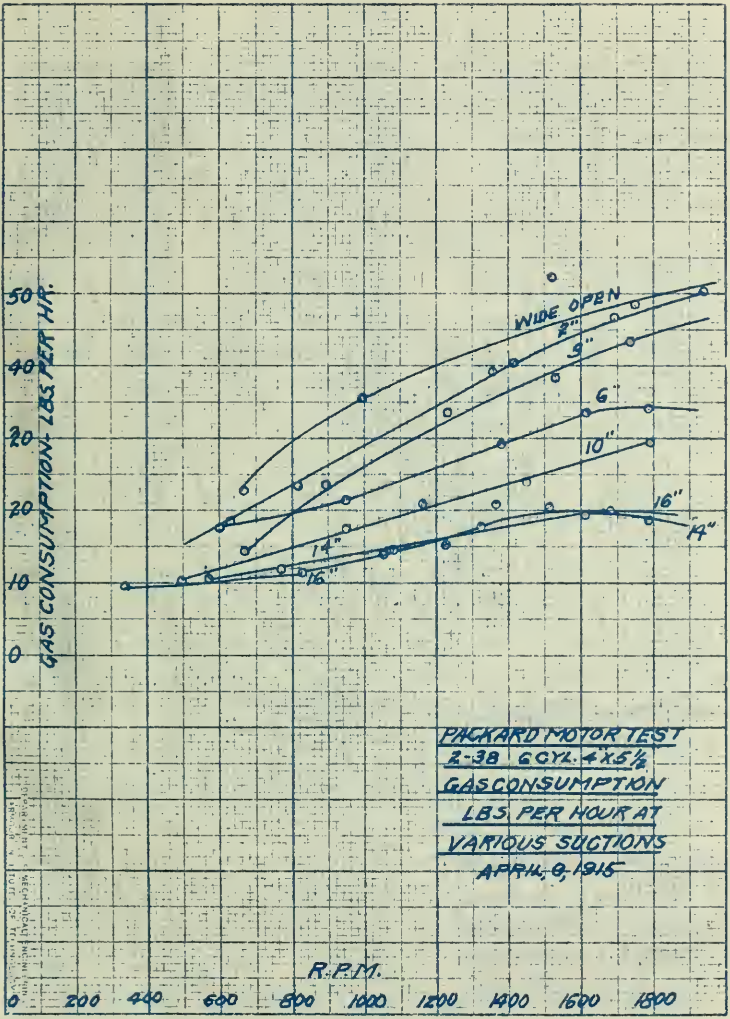
RUN NO.	R.P.M.	TORQUE	F.H.P.	SUCTION INTAKE IN. HG.	TEMP. COOLING WATER DEG. F.	
					INLET	OUTLET
1	222	24.0	1.33	16	107	108
2	340	28.25	2.4	16	108	109
3	476	31.75	3.77	16	108	109
4	616	37.75	5.81	16	108	109
5	744	41.5	7.76	16	108	109
6	854	44.5	9.5	16	108	109

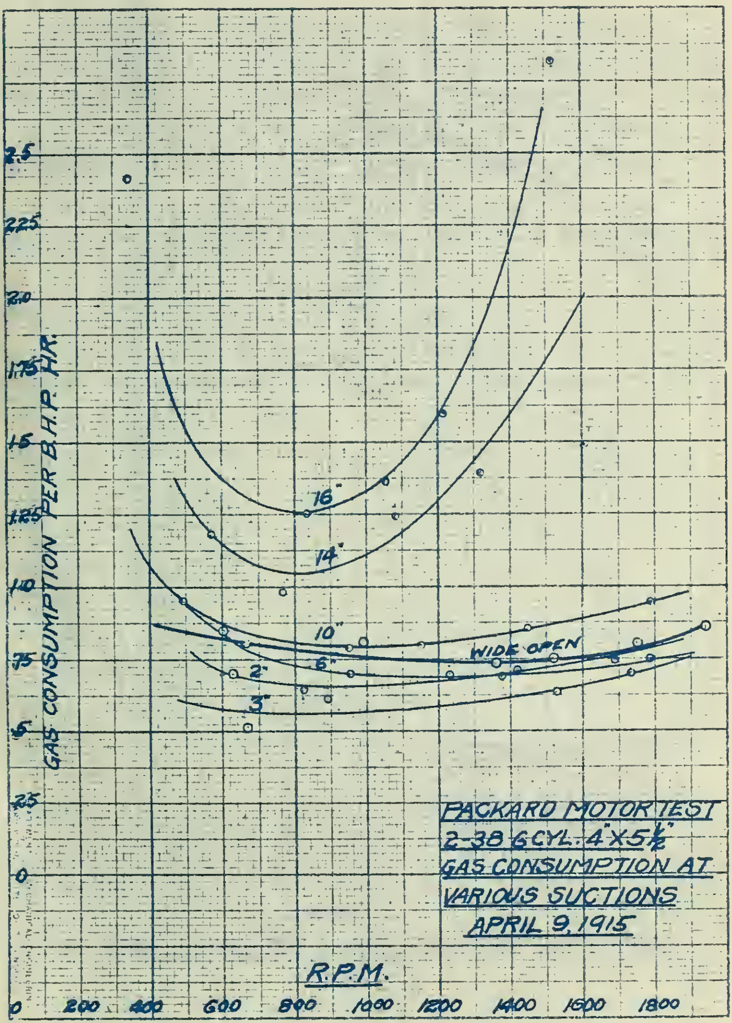

PACKARD MOTOR TEST
BRAKE HORSE POWER
AT VARIOUS SUCTIONS
2-38 6 CYL. 4"X5½"
APRIL 9, 1915
B.H.P.
R.P.M.
WIDE OPEN THROTTLE
2"
3"
6"
10"
14"
16"
0
10
20
30
40
50
60
0
200
400
600
800
1000
1200
1400
1600
1800

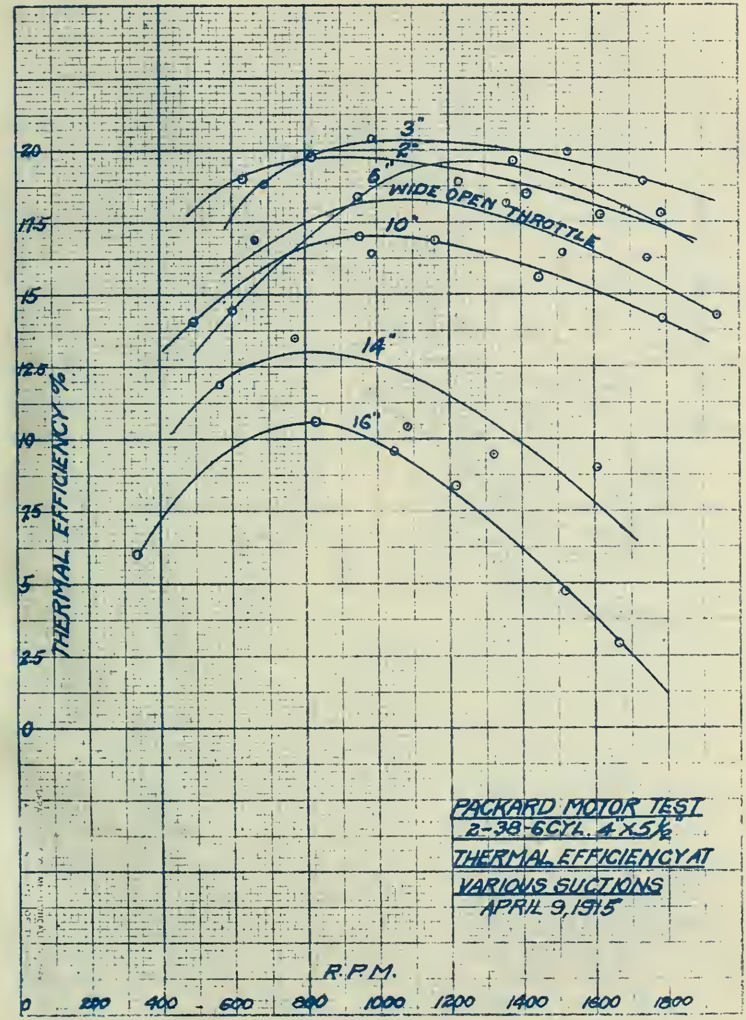

PACKARD MOTOR TEST
2-38 6CYL 4x5½
INDICATED HORSEPOWER
APRIL 9, 1915
INDICATED HORSEPOWER
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800
10
20
30
40
50
60
70
80
90
100
2"
WIDE OPEN
10"
16"

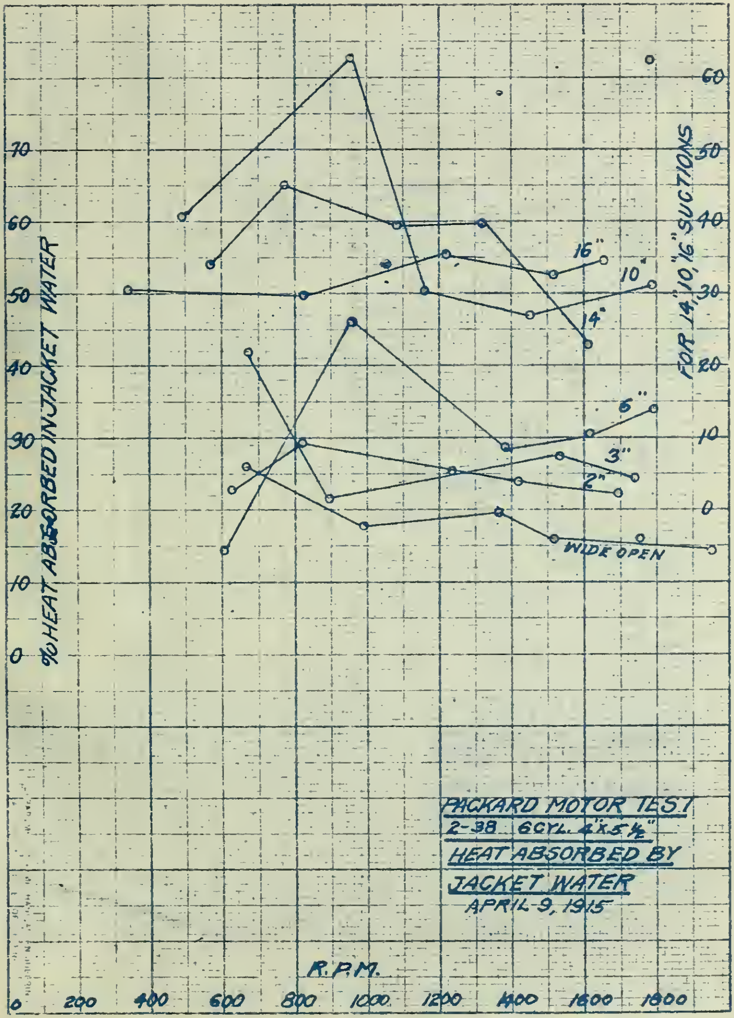


INDICATED HORSE POWER
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
1800
R.P.M.
3"
6"
14"
PACKARD MOTOR TEST
2-38 6CYL. 4×5½"
INDICATED HORSEPOWER
APRIL 9, 1915

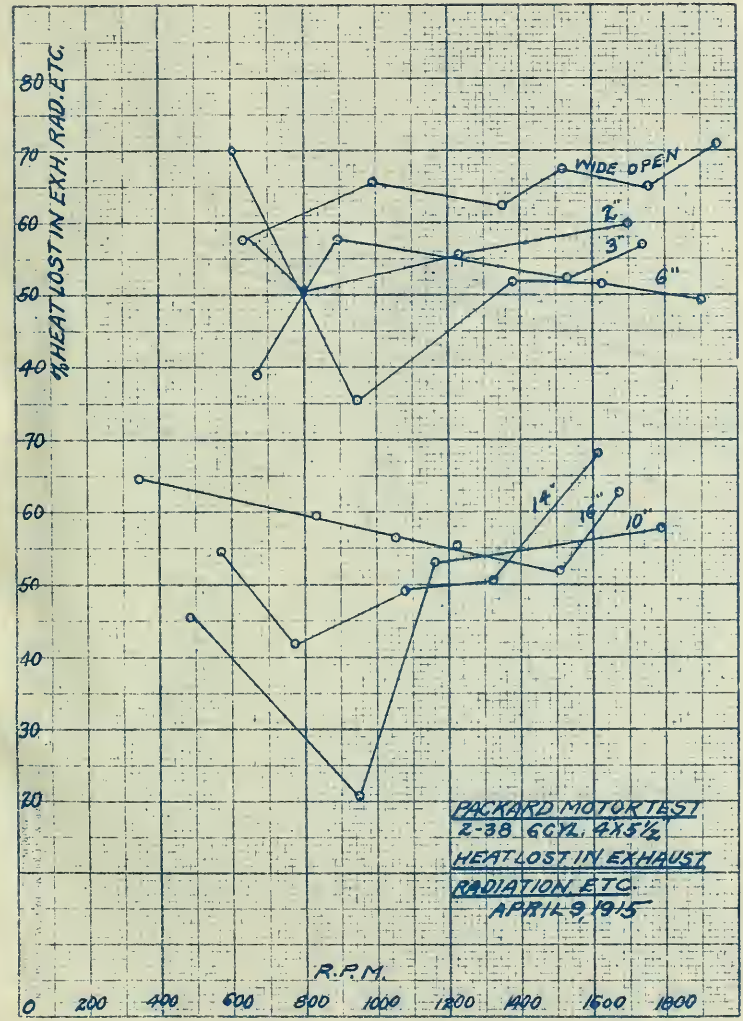

GAS CONSUMPTION - LBS PER HR.
50
40
30
20
10
0
WIDE OPEN
2"
3"
6"
10"
14"
16"
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800
PACKARD MOTOR TEST
2-38 6 CYL. 4" X 5 1/2
GAS CONSUMPTION
LBS. PER HOUR AT
VARIOUS SUCTIONS
APRIL, 8, 1915

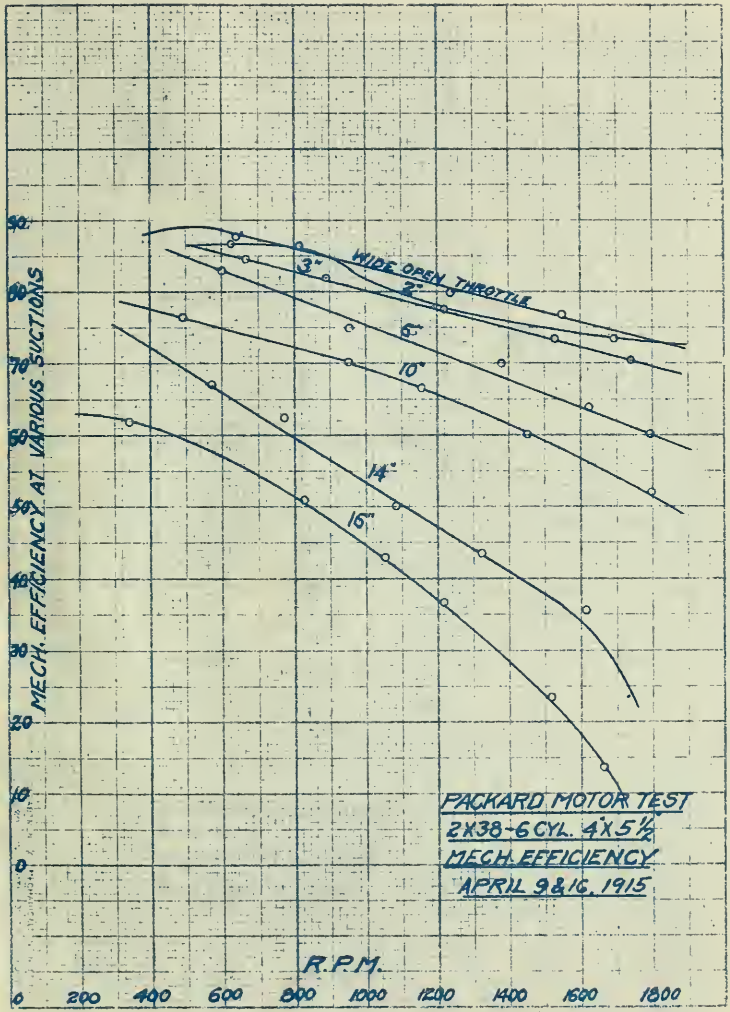

GAS CONSUMPTION PER B.H.P. HR.
2.5
2.25
2.0
1.75
1.5
1.25
1.0
.75
.5
.25
0
16"
14"
10"
WIDE OPEN
6"
2"
3"
PACKARD MOTOR TEST
2-38 6 CYL. 4"X5½"
GAS CONSUMPTION AT
VARIOUS SUCTIONS
APRIL 9, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800

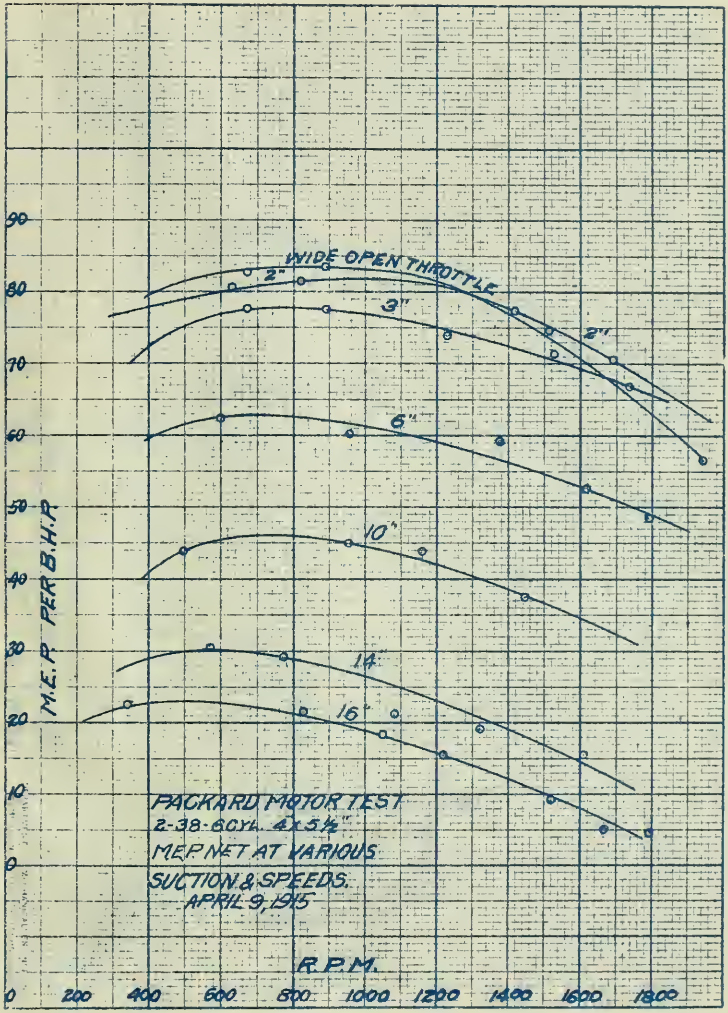

3"
2"
6"
WIDE OPEN THROTTLE
10"
14"
16"
THERMAL EFFICIENCY %
20
17.5
15
12.5
10
7.5
5
2.5
0
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800
PACKARD MOTOR TEST
2-38-6CYL. 4"X5½"
THERMAL EFFICIENCY AT
VARIOUS SUCTIONS
APRIL 9, 1915

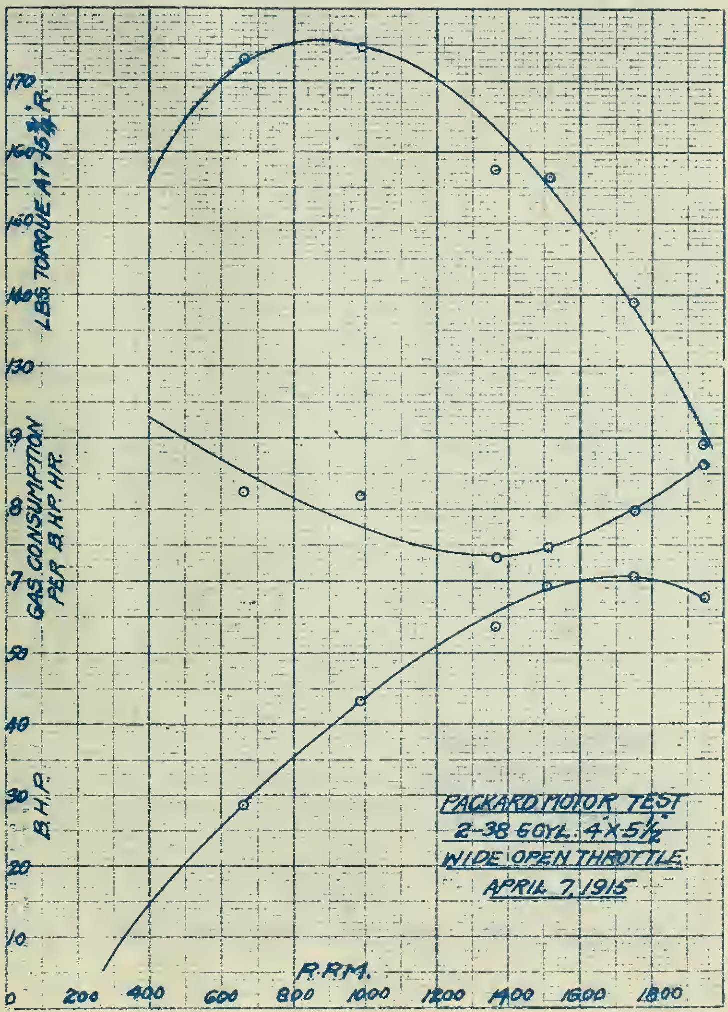


% HEAT ABSORBED IN JACKET WATER
FOR 14", 10", 16" SUCTIONS
16"
10"
14"
6"
3"
2"
WIDE OPEN
PACKARD MOTOR TEST
2-38 6 CYL. 4" x 5 1/2"
HEAT ABSORBED BY
JACKET WATER
APRIL 9, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800
10
20
30
40
50
60
70

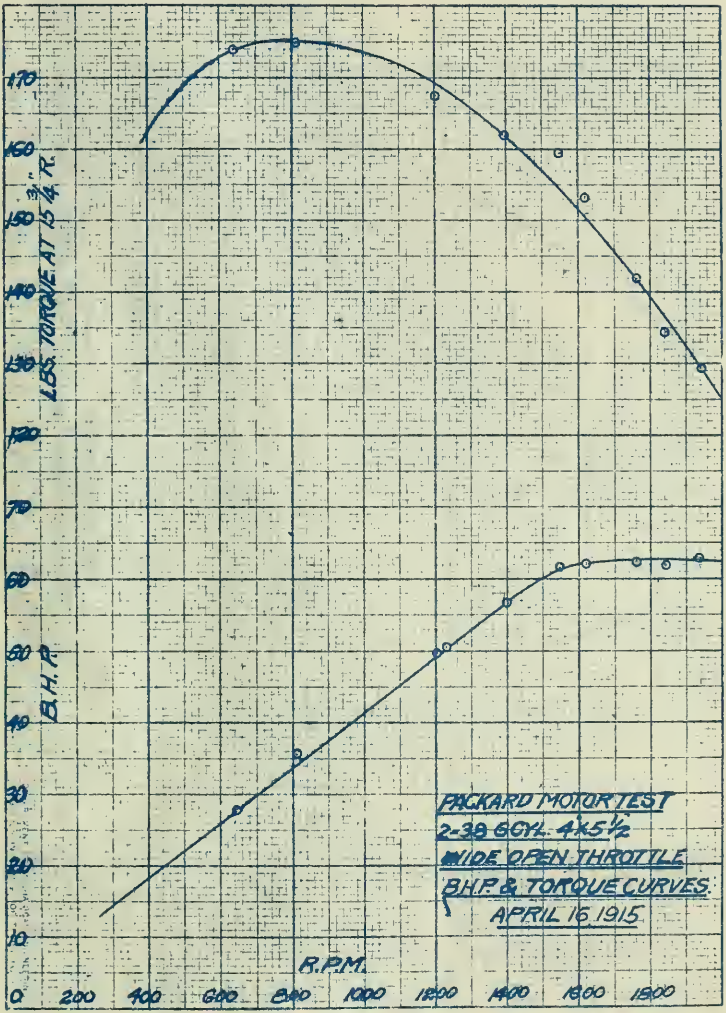

% HEAT LOST IN EXH. RAD. ETC.
80
70
60
50
40
70
60
50
40
30
20
WIDE OPEN
2"
3"
6"
14"
16"
10"
PACKARD MOTOR TEST
Z-38 6 CYL. 4 X 5½
HEAT LOST IN EXHAUST
RADIATION, ETC.
APRIL 9, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800

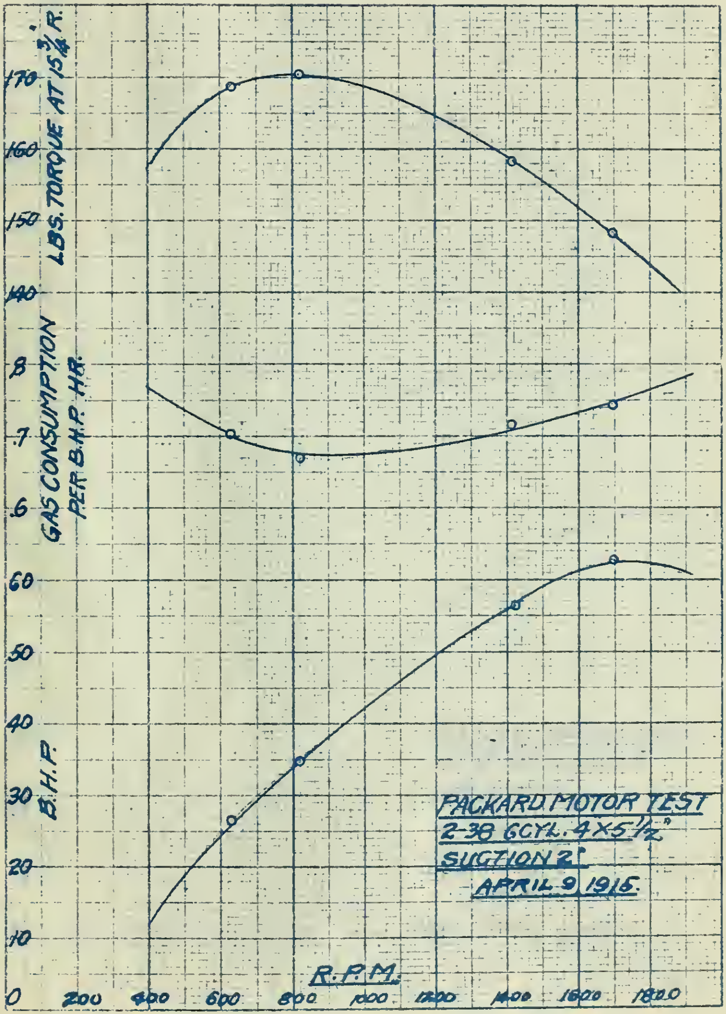

MECH. EFFICIENCY AT VARIOUS SUCTIONS
90
80
70
60
50
40
30
20
10
0
WIDE OPEN THROTTLE
3"
2"
6"
10"
14"
16"
PACKARD MOTOR TEST
2X38-6 CYL. 4"X 5½"
MECH. EFFICIENCY
APRIL 9 & 16, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800

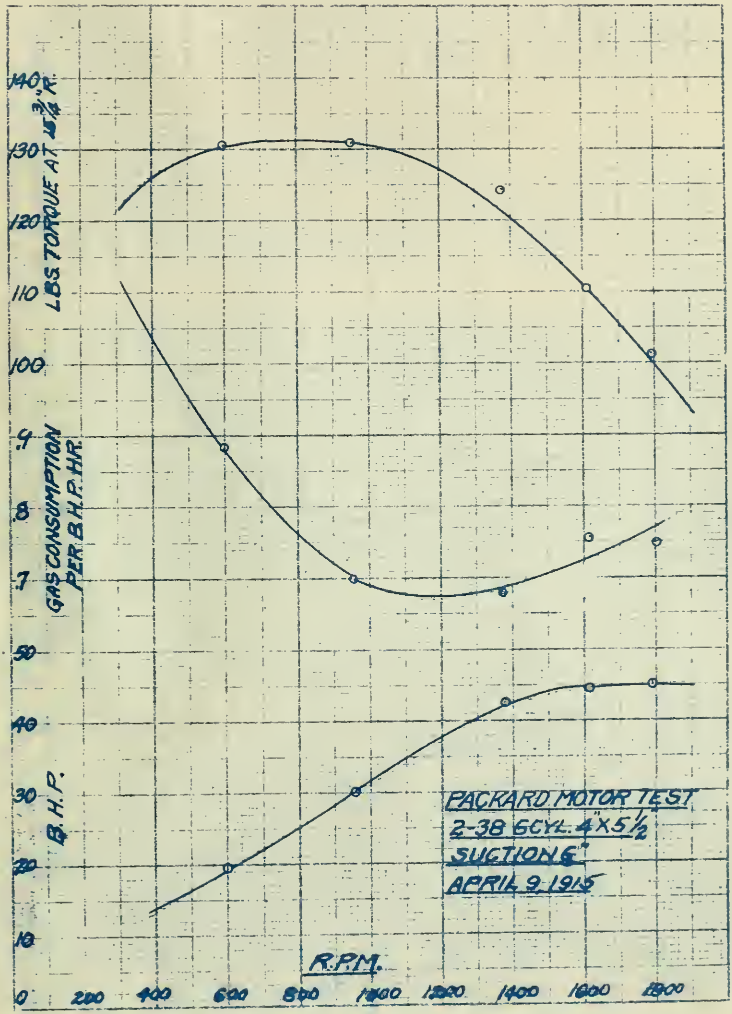

WIDE OPEN THROTTLE
2"
3"
2"
6"
10"
14"
16"
M.E.P. PER B.H.P.
90
80
70
60
50
40
30
20
10
0
PACKARD MOTOR TEST
2-38-6CYL. 4 x 5½"
M.E.P. NET AT VARIOUS
SUCTION & SPEEDS.
APRIL 9, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800



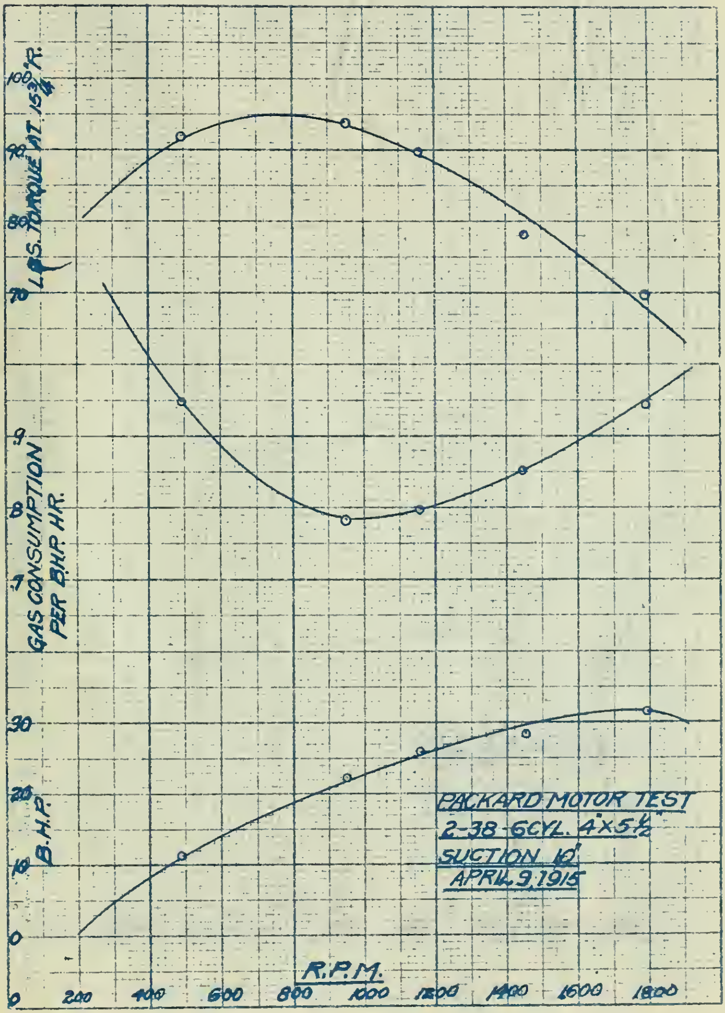
LBS. TORQUE AT 15¾" R.
GAS. CONSUMPTION PER B.HP. HR.
B.H.P.
170
160
150
140
130
.9
.8
.7
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
1800
R.P.M.
PACKARD MOTOR TEST
2-38 6 CYL. 4 X 5½
WIDE OPEN THROTTLE
APRIL 7, 1915


170
160
150
140
130
120
70
60
50
40
30
20
10
0
LBS. TORQUE AT 15 3/4" R.
B.H.P.
R.P.M.
200
400
600
800
1000
1200
1400
1600
1800
PACKARD MOTOR TEST
2-38 6CYL. 4x5 1/2
WIDE OPEN THROTTLE
B.H.P. & TORQUE CURVES.
APRIL 16 1915

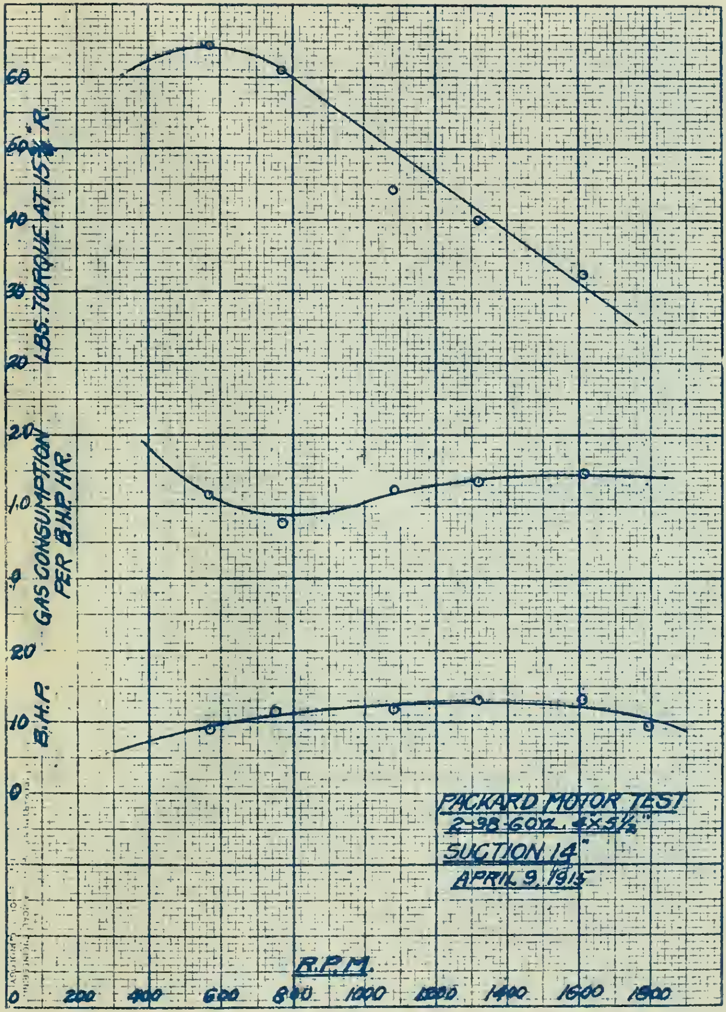

LBS. TORQUE AT 15¾" R.
GAS CONSUMPTION PER B.H.P. HR.
B.H.P.
170
160
150
140
.8
.7
.6
60
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
1800
R.P.M.
PACKARD MOTOR TEST
2-38 6CYL. 4X5½"
SUCTION 2"
APRIL 9 1915.

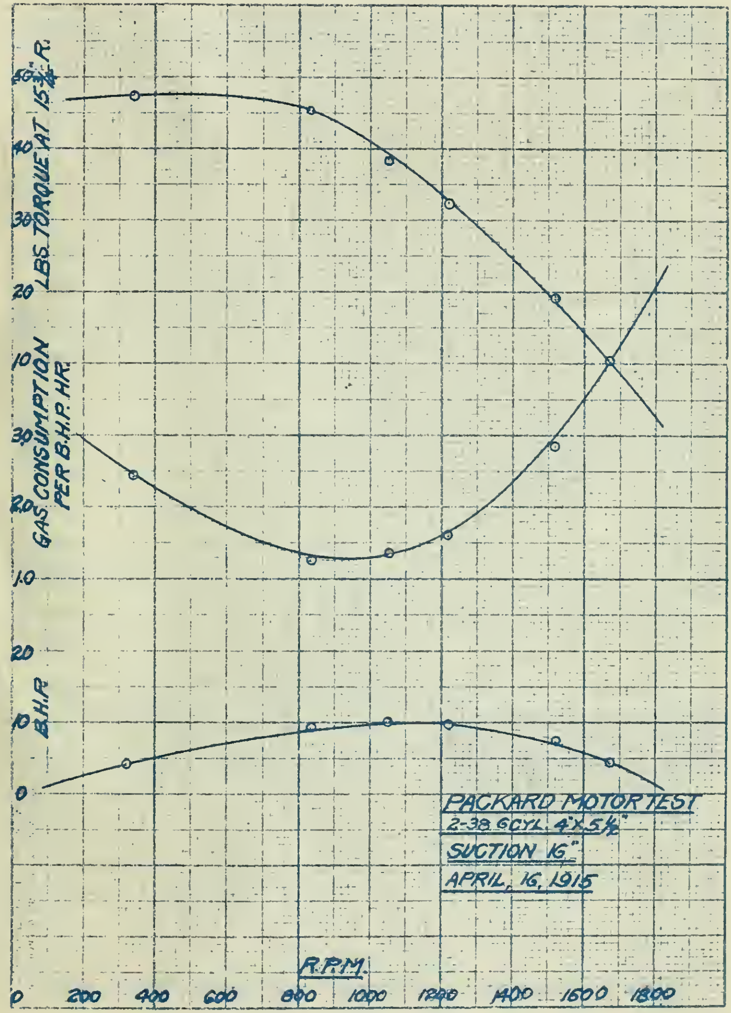


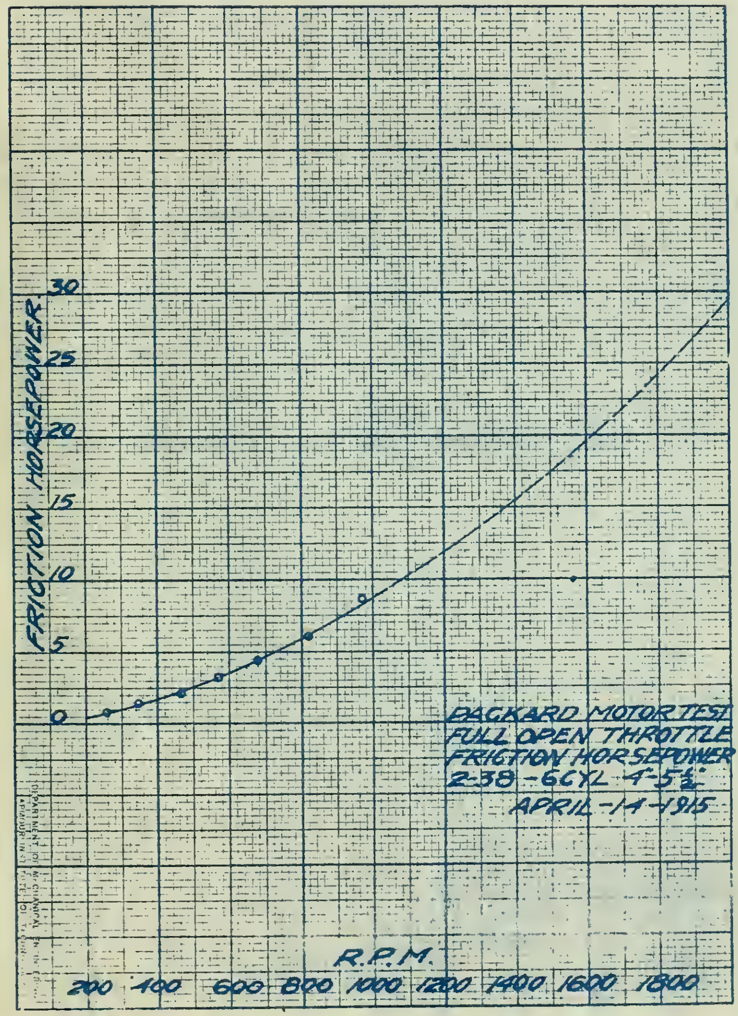
LBS TORQUE AT 15 3/4" R.
GAS CONSUMPTION PER B.H.P. HR.
B.H.P.
140
130
120
110
100
.9
.8
.7
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
1800
R.P.M.
PACKARD MOTOR TEST
2-38 6CYL. 4"X5 1/2
SUCTION 6"
APRIL 9 1915

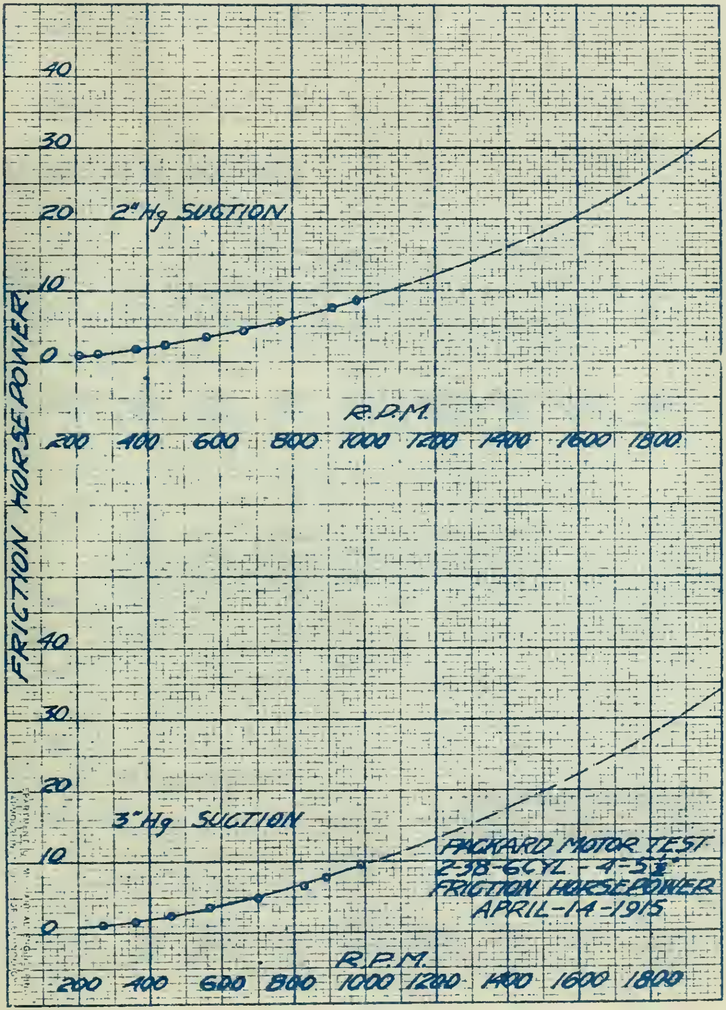


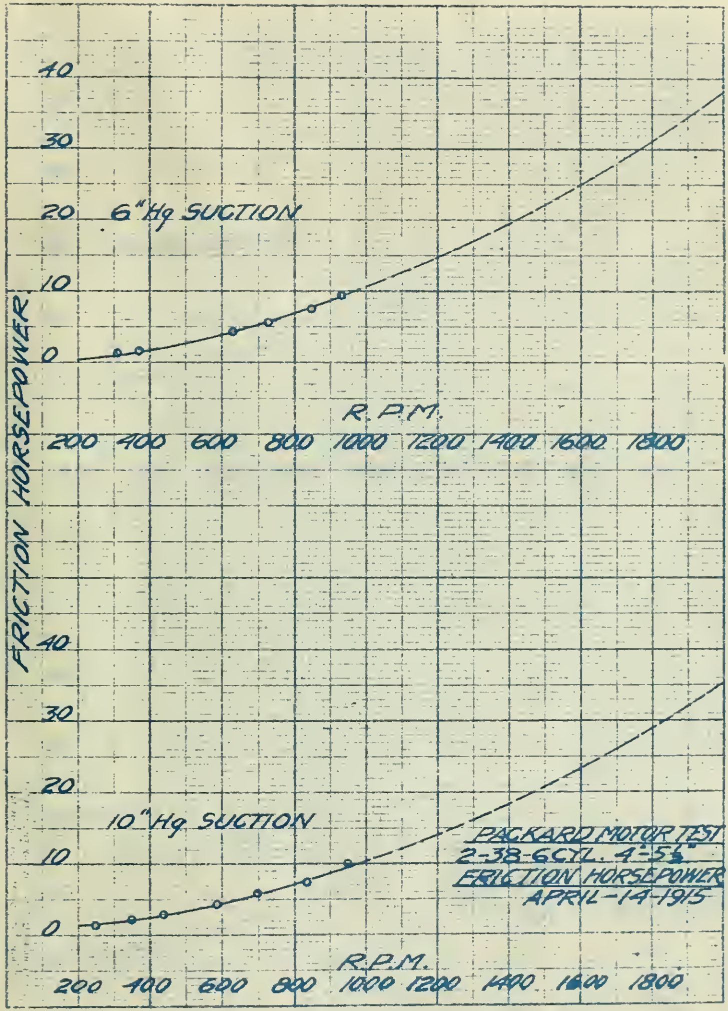
LBS. TORQUE AT 15 3/4" R.
100
90
80
70
GAS CONSUMPTION PER B.H.P. H.R.
9
8
7
B.H.P.
30
20
10
0
PACKARD MOTOR TEST
2-38-6CYL. 4"×5 1/2
SUCTION 10"
APRIL 9.1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800

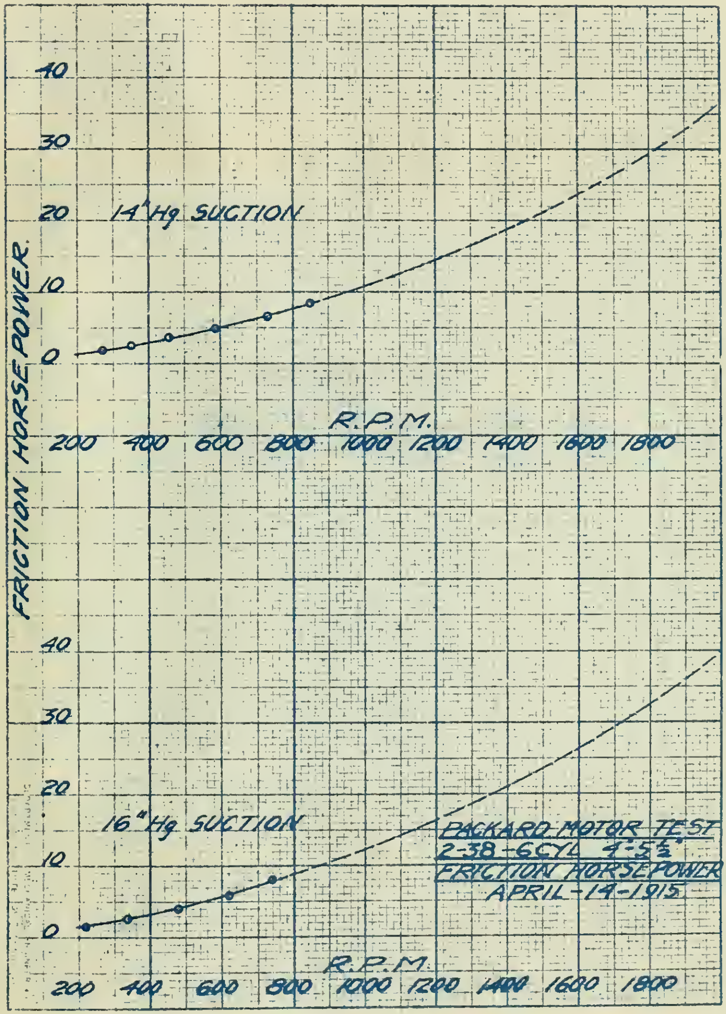

60
50
40
30
20
LBS. TORQUE AT 15¾" R.
2.0
1.0
.9
GAS CONSUMPTION PER B.H.P. HR.
20
10
0
B.H.P.
PACKARD MOTOR TEST
2-38-6CYL. 4X5½"
SUCTION 14"
APRIL 9, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800


LBS. TORQUE AT 15¾" R.
GAS CONSUMPTION PER B.H.P. HR.
B.H.P.
PACKARD MOTOR TEST
2-38 6 CYL. 4"X 5½"
SUCTION 16"
APRIL, 16, 1915
R.P.M.
0
200
400
600
800
1000
1200
1400
1600
1800
10
20
30
40
1.0
2.0
3.0


FRICTION HORSEPOWER
30
25
20
15
10
5
0
PACKARD MOTOR TEST
FULL OPEN THROTTLE
FRICTION HORSEPOWER
2-38 - 6CYL 4"-5½"
APRIL-14-1915
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800


FRICTION HORSE POWER
40
30
20
2" Hg SUCTION
10
0
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800
40
30
20
3" Hg SUCTION
10
0
PACKARD MOTOR TEST
2-38-6CYL - 4-5½"
FRICTION HORSEPOWER
APRIL-14-1915
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800


FRICTION HORSEPOWER
6" Hg SUCTION
40
30
20
10
0
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800
10" Hg SUCTION
40
30
20
10
0
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800
PACKARD MOTOR TEST
2-38-6CYL. 4"-5½"
FRICTION HORSEPOWER
APRIL-14-1915

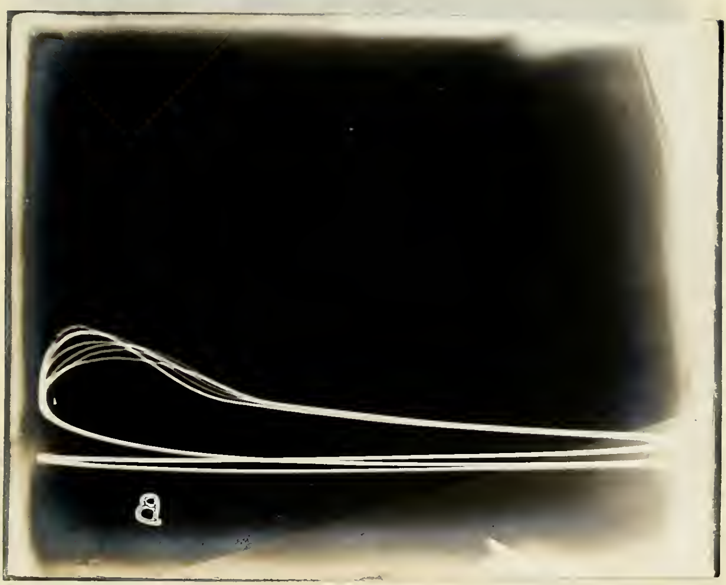

FRICTION HORSEPOWER.
14" Hg SUCTION
R.P.M.
200 400 600 800 1000 1200 1400 1600 1800
0 10 20 30 40
16" Hg SUCTION
R.P.M.
PACKARD MOTOR TEST
2-38-6CYL 4"-5½"
FRICTION HORSEPOWER
APRIL-14-1915

Monograph Cards
for
Different Speeds, Loads, and
Suction Pressures.

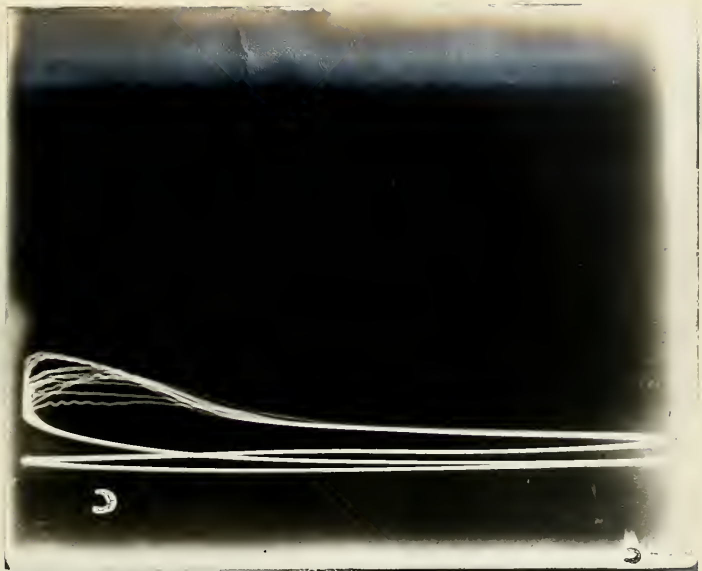
Suction	16 inches.
R. P. M.	666
Torque	44.7
Spark	40
B. H. P.	7.45


A

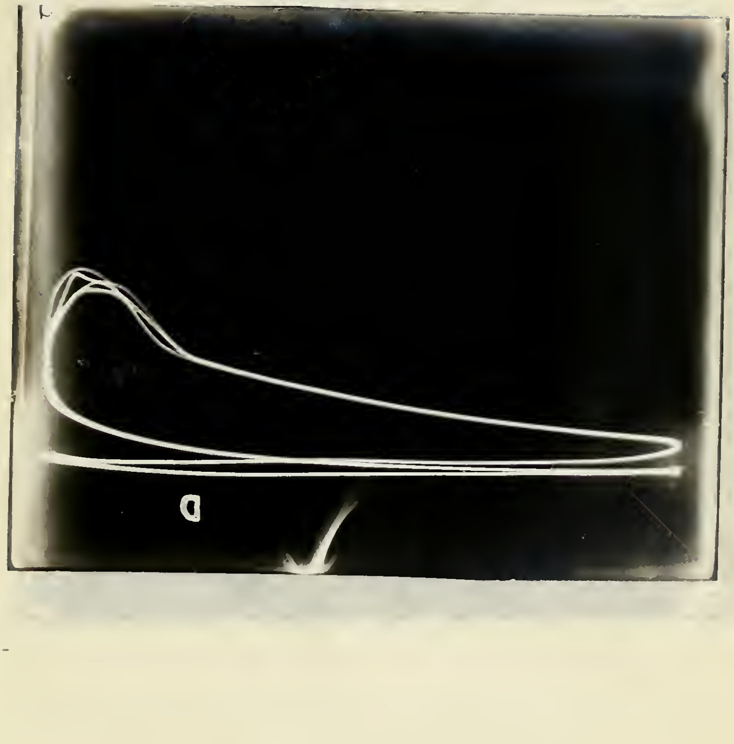
Suction	16 inches.
R. P. M.	890
Torque	31.0
Spark	40
B. H. P.	6.9


a

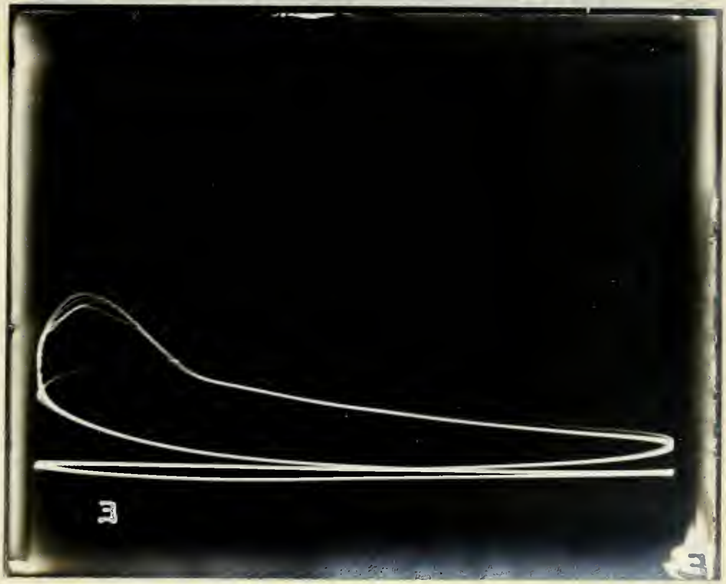
Suction	16 inches
R. P. M.	16.8
Torque	12
Spark	40
B. H. P.	4.85



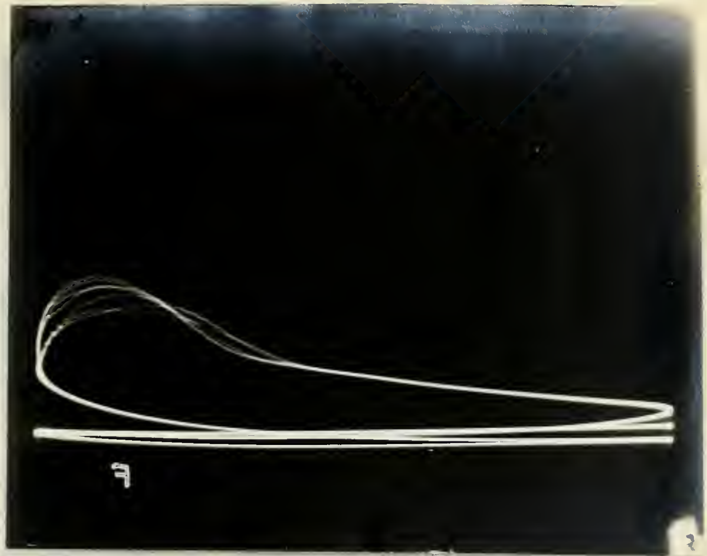
Suction	14 inches.
R. P. M.	670
Torque	63
Spark	40
B. H. P.	10.55



Suction	14 inches
R. P. M.	884
Torque	63.5
Spark	40
B. H. P.	14.0

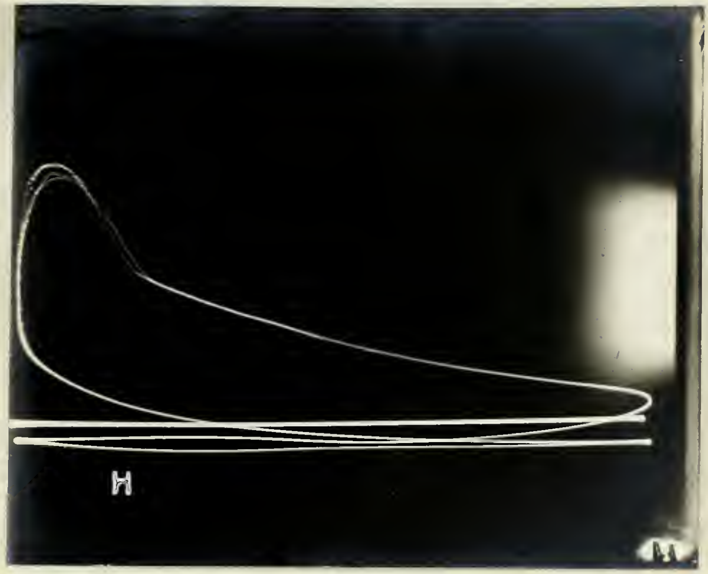


Suction	14 inches
R. P. M.	1098
Torque	54.0
Spark	40
B. H. P.	14.85



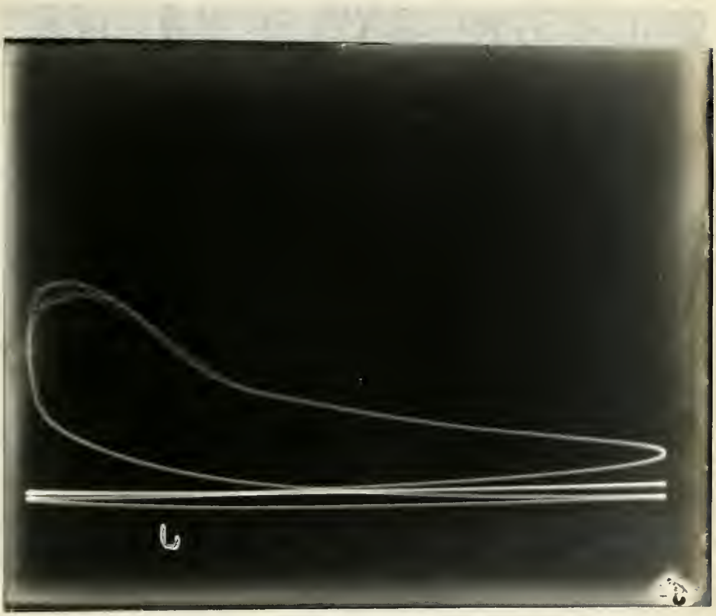
Suction	14 inches
R. P. M.	1522
Torque	45
Spark	40
B. H. P.	16.75

Suction	10 inches
R. P. M.	724
Torque	100
Spark	40
B. H. P.	18.1


H

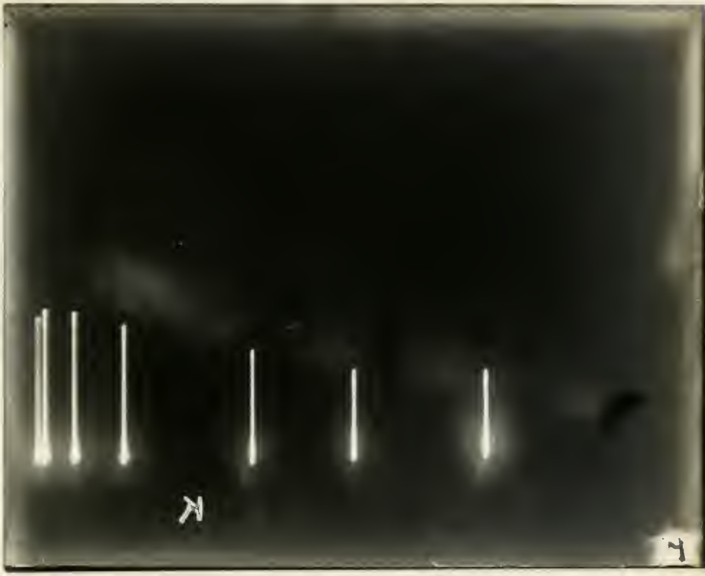
Suction	10 inches
R. P. M.	1000
Torque	99
Spark	40
B. H. P.	24.8

Suction	10 inches
R. P. M.	1650
Torque	31
Spark	40
B. H. P.	12.8



Compression Card.

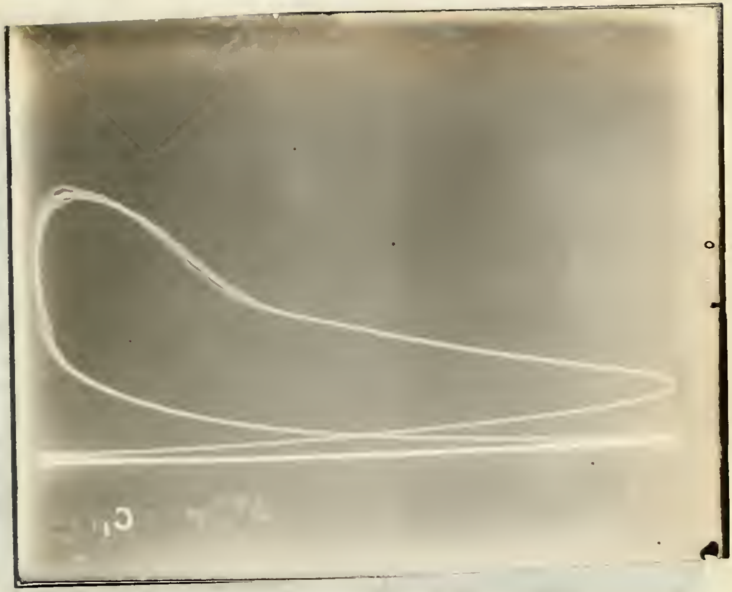
R.P.M.	Suction.
620	1/2
850	7/8
1025	1-1/8
1225	1-3/8
1475	1-5/8
1925	2-1/8
2000	2-1/4



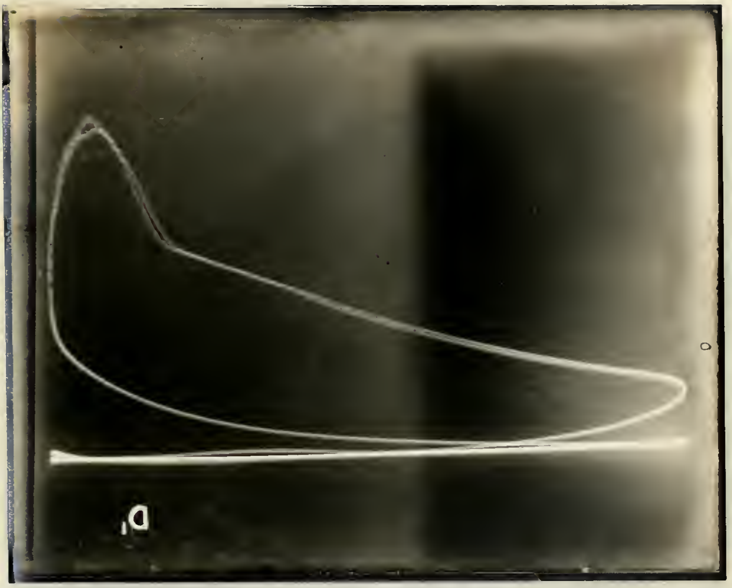
Suction	6 inches
R. P. M.	682
Torque	126.5
Spark	34
B. H. P.	21.6

Suction	6 inches
R. P. M.	1064
Torque	123.0
Spark	40
B. H. P.	32.8

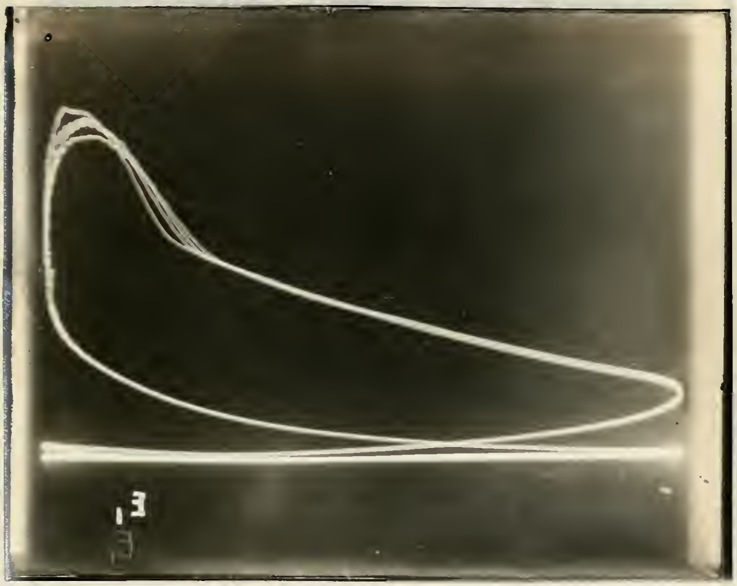
Suction	6 inches.
R. P. M.	1508
Torque	112
Spark	40
B. H. P.	42.3



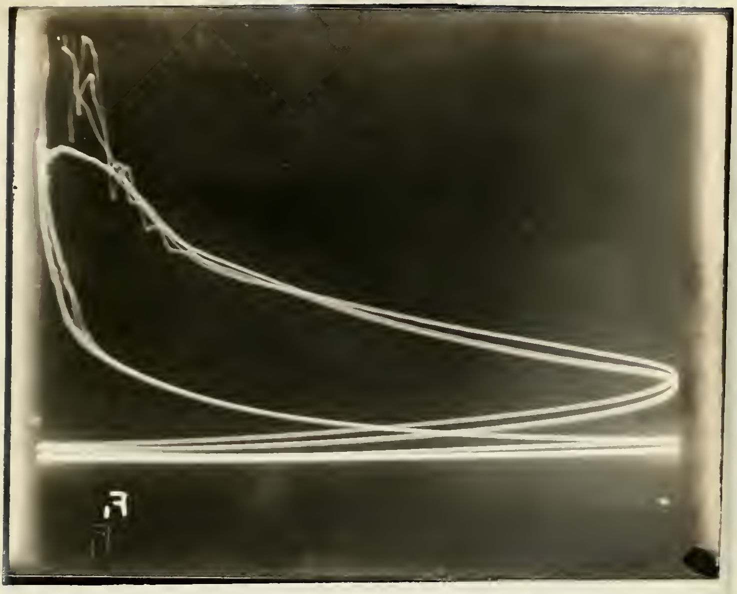
Suction	3 inches.
R. P. M.	692.
Torque	158
Spark	32
B. H. P.	27.3



Suction	3 inches
R. P. M.	1178.
Torque	157
Spark	38
B. H. P.	46.1

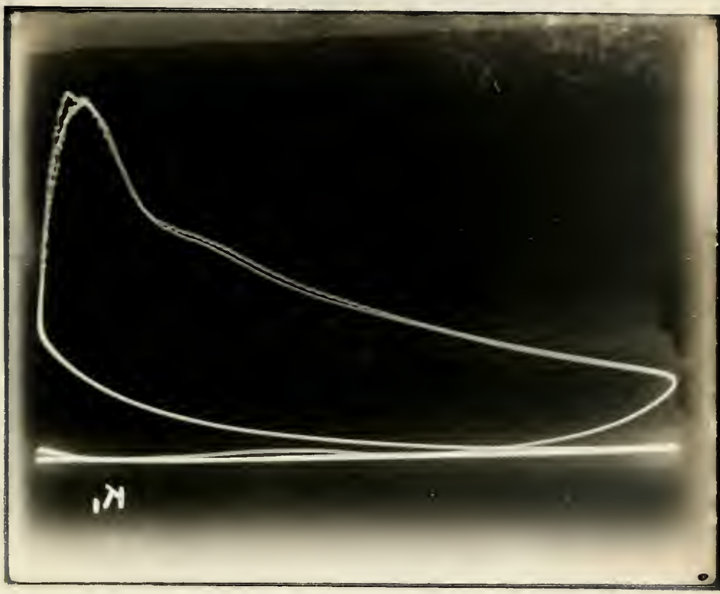


Suction	3 inches
R. P. M.	1572
Torque	144.5
Spark	40
B. H. P.	56.8



Suction - Wide Open Throttle.

R. P. M.	584
Torque	160
Spark	25
B. H. P.	23.4

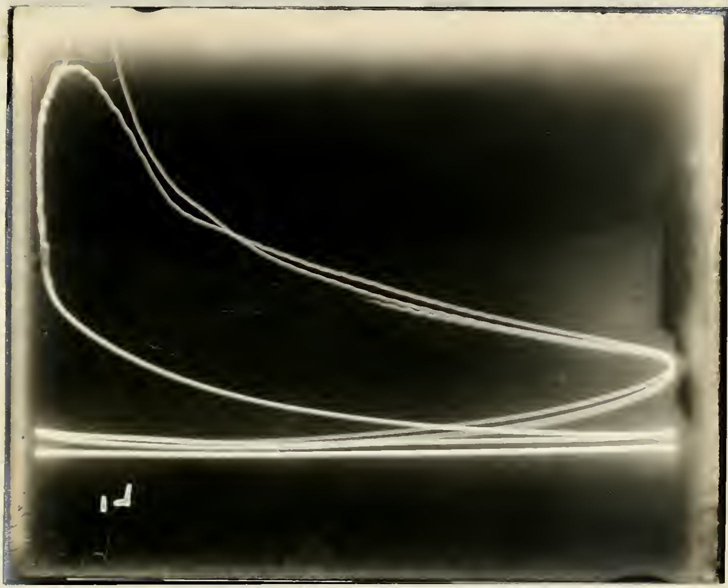


Suction - Wide Open Throttle.

R. P. M.	584
Torque	160
Spark	25
B. H. P.	23.4

Suction - Wide Open Throttle

R. P. M.	1064.
Torque	175.
Spark	32
B. H. P.	46.5

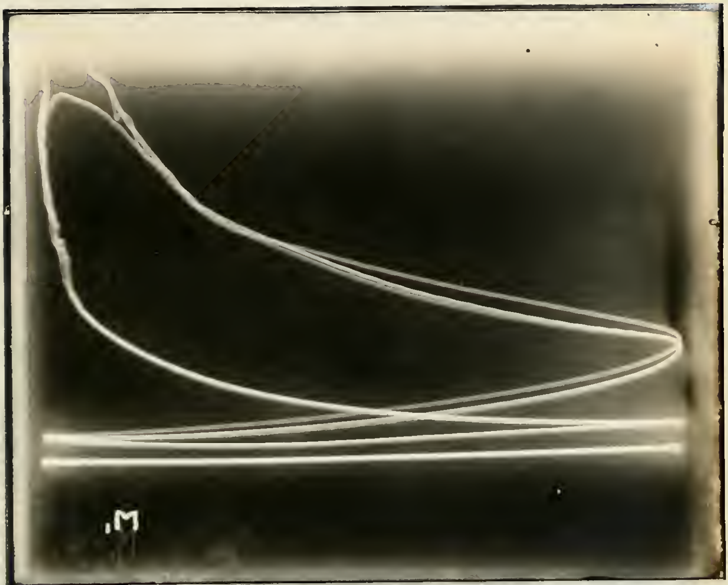


Suction   2 inches. Wide Open Throttle

R. P. M.	1534
Torque	157
Spark	40
B. H. P.	60.2

Suction 2 inches. Wide open Throttle.

R. P. M.	1534
Torque	157
Spark	40
B. H. P.	60.2


M

Compression Card

Suction	16 inches.

R. P. M.

540
690
860
1050
1175
1176


Ca

Compression Card

Suction 14 inches.

R. P. M.
490
650
850
1050
1225
1375
1550
1700
1840

Compression Card

Suction	10 inches

R. P. M.

555
650
820
975
1175
1350
1500
1650
1875

Compression Card

Suction 6 inches.

R. P. M.
560
740
925
1075
1250
1375
1500
1700
1800

Compression Card.

Suction 3 inches.

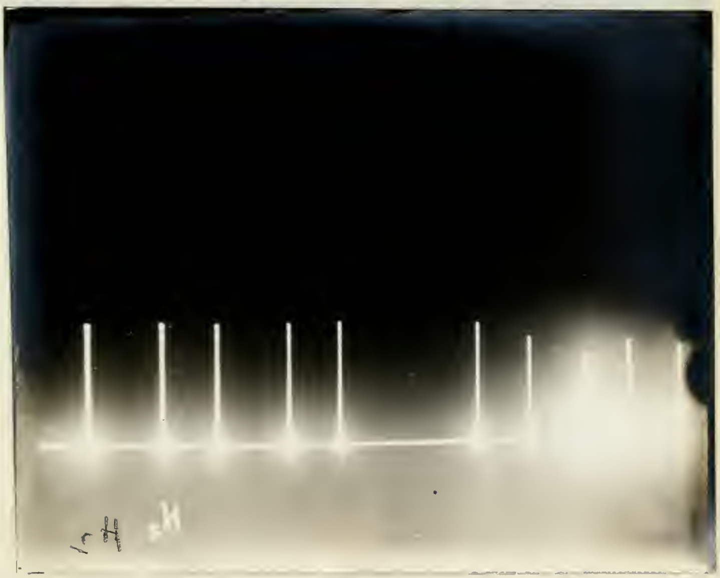
R. P. M.

520
690
900
1050
1225
1375
1550
1750
1850

Compression Card

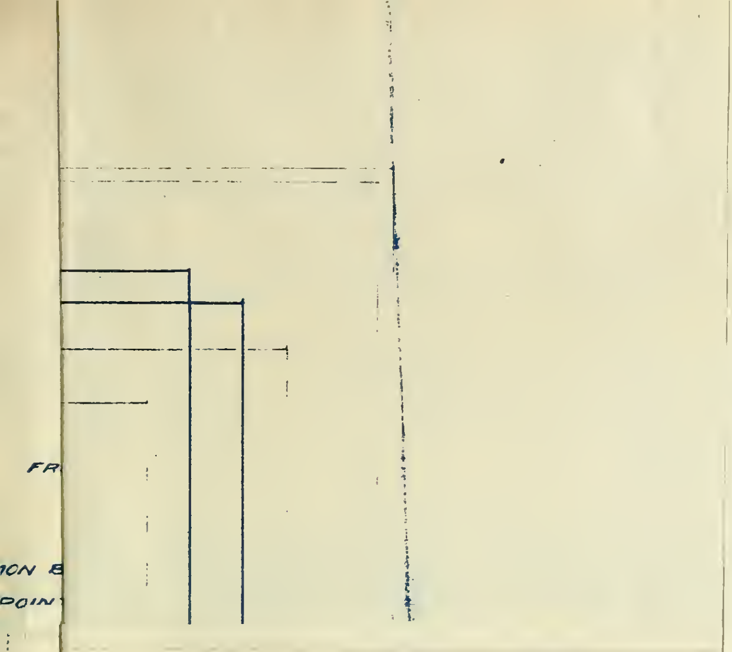
Suction 2 inches.

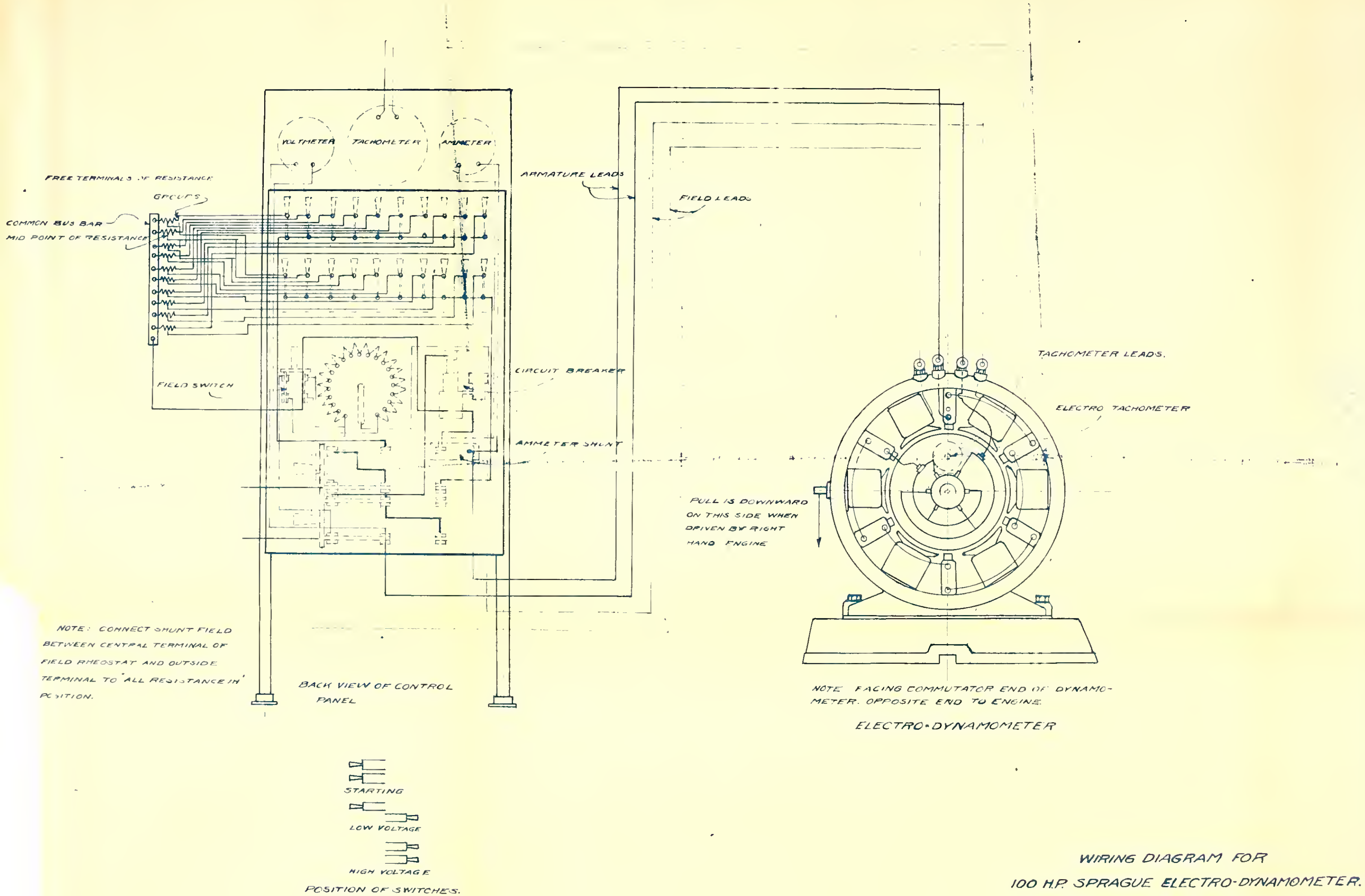
R. P. M.
515
700
850
1000
1125
1275
1450
1600
1700
1900



Compression Card

R.P.M.	Wide Open Throttle. Suction
500	3/4
675	13/16
960	1-1/8
1075	1-3/8
1300	1-3/4
1500	2-1/8
1700	2-3/4
1900	3
1925	3-1/8





WIRING DIAGRAM FOR
100 H.P. SPRAGUE ELECTRO-DYNAMOMETER.
AS INSTALLED AT ARMOUR INSTITUTE OF TECHNOLOGY.
DRAWN BY: H D GUMPPER, MAY 28, 1914